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GEOLOGICAL SURVEY OF CANADA
ROBERT BELL, M.D., Sc.D. (CANTAB), LL.D., F.R.S.

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# REPORT

ON THE

# CAMBRIAN ROCKS

OF

# CAPE BRETON

BY

G. F. MATTHEW, LL.D., D.Sc., F.R.S.C.

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1903

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To Robert Bell, M.D., Sc.D., F.R.S., etc.,
Director Geological Survey of Canada.

Sir,—I have the honour to submit herewith my report on the special work, undertaken at the instance of the late Director of the Survey, on the Cambrian area in Cape Breton, N.S. This work, begun in 1899, has been delayed by the shortness of time at my disposal for investigation each year, making it necessary for me to revisit the island to complete necessary observations.

I am, sir,
Your obedient servant,

G. F. MATTHEW.

# REPORT

ON THE

# CAMBRIAN ROCKS OF CAPE BRETON

In the spring of 1899 I received the following letter from the late Dr. G. M. Dawson, at that time Director of the Canadian Geological Survey :— Instructions from Dr. G. M. Dawson.

'DEAR DR. MATTHEW,—In thinking over work for the coming summer it occurs to me to ask whether it would be agreeable to you to undertake a field examination, for such time as you could spare, of the Cambrian rocks in Cape Breton island, followed subsequently by such study of the fossils obtained as might be necessary for their determination and description. We seem to know very little about the Cambrian and possible Cambro-Silurian rocks of Cape Breton, although Mr. Fletcher, on stratigraphical grounds, seems to think that there is a great thickness, which may represent a number of horizons.'

These clauses of Dr. Dawson's letter seemed to present to me the kind of investigation which he wished made in Cape Breton, and were taken as directive of the work which I subsequently arranged with him to do there. The short time at my disposal in three successive summers was given to this exploration, and intervals of leisure during the three years have been spent in working up the results of the field exploration.

I was guided by Mr. Hugh Fletcher in selecting areas where it was thought the best results could be obtained, and for this reason my work was confined to the Barachois basin on St. Andrews Channel, to Indian Brook basin and several smaller areas on East Bay, and to the most important parts of the valley of the Mira river. There are some other small areas of Cambrian rocks in the island of Cape Breton, but these Mr. Fletcher did not think would yield results such as I sought, and so they were not visited. Mr. Hugh Fletcher's assistance.

The object of my visit then was to study the thickness, succession and distribution of the several members of the Cambrian system ; and

to collect and determine the fossils which they might be found to contain. In thus ascertaining the relation of the several parts of the Cambrian terranes to each other, and their distribution, a guide would be had also to the location of mineral deposits which the Cambrian rocks might contain.

## INTRODUCTORY.

### THE STRUCTURE OF THE CAMBRIAN ROCKS IN CAPE BRETON, AND THEIR CONTAINED FAUNAS.

edge of ian ed. Since the survey of the Cambrian areas in Cape Breton was made by Mr. Hugh Fletcher some twenty-five years ago, our knowledge of the Cambrian system in America has been greatly extended, notably by the explorations of the United States Geological Survey, and through the efforts of its present able director. Much also has been done by the Canadian Survey, especially in the region of the Rocky mountains, the valley of the St. Lawrence, and in Labrador.

In the province of New Brunswick the structure and faunas of the Cambrian rocks have been worked out by private effort, and from their proximity to Cape Breton are most reliable for comparison with those of that island. The series there also is so complete that it yields a good standard of comparison for all the Atlantic coast Cambrian deposits.

survey er. After the exploratory work of the Canadian Geological Survey had been opened in Cape Breton, Mr. Fletcher, in 1874, began the study of the areas where the Cambrian rocks are found, and continued his work there for three years, when the further prosecution of the survey carried him beyond the Cambrian areas.

In the progress of Mr. Fletcher's work in the Cambrian districts he had found that the sediments of this age lie in several narrow valleys inclosed between abrupt hills of Pre Cambrian rocks, mostly crystalline or metamorphic; and in one broader valley, that of the Mira river. It was in the valley of this river that the fossils were found, which determined the Cambrian age of the above mentioned rocks in Cape Breton.

The carefully delineated topographical details given by Mr. Fletcher in his excellent maps, the record of the dips and strikes of the rocks, of the nature of the sediments, and of the localities where fossils were to be had, materially aided the writer in investigating the geology of

this district. The writer would also acknowledge valuable personal assistance from Mr. Fletcher, rendered at the instance of the Director of the Survey.

References to Cambrian rocks.

In addition to the geological map of Cape Breton, on which the Cambrian areas are depicted, references to the Cambrian rocks of the island by Mr. Fletcher will be found in the Reports of Progress of the Geological Survey, year 1875-6, pages 389 to 393; year 1876-7, pages 428 to 437; and year 1877-8, pages 11F to 16F. In these reports the rocks are described under the head of Lower Silurian, as at that time the Cambrian was not fully recognized in America as a system with distinctive faunas separate from the Lower Silurian.

Mr. Fletcher explored two narrow valleys of Cambrian rocks on St. Andrews channel, connected with the Boisdale hills, and two others on East bay, in the Coxheath hills. In all these he found the strata highly inclined, and in many of his notes only the strike is recorded. In the larger Cambrian district on the Mira river also, the strata dip at a high angle, so that the structure cannot be inferred from the details given. Thus the structure and succession of the beds could not be determined without some further study in the field. I therefore gave some attention to the distribution of the strata before collecting materials for the study of the fossils. This preliminary work was of importance as it enabled me to place one of the faunas at a horizon lower than the biological indications had warranted.

## CAMBRIAN STANDARDS.

Cambrian system in Sweden.

The standards used for comparison of the faunas are those of Great Britain and Sweden. In the lower members of the Cambrian deposits of Sweden the faunas are poor and wanting in variety, but the Middle and Upper Cambrian have a full and rich succession of faunas. The richness of the Cambrian faunas of Sweden in trilobites allows of very exact and minute distinctions between the several layers, so that the succession groups have been distinguished by the several faunas which they contain; and we also have an upward succession of groups each distinguished by a leading genus of trilobites, or other organism, as:—

Olenellus (Holmia) fauna.
Lower Paradoxides beds.
Upper Paradoxides beds.
Olenus beds or fauna.
Peltura beds or fauna.
Dictyonema fauna.

The Ceratopyge fauna which follows, and which is equivalent in age to the Tremadoc slates of Wales, is considered by the Swedes and Germans to be a part of the Ordovician, or Lower Silurian system.

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In Wales there is a great development of the Cambrian system, the thickness from detrital sources being increased by additions of volcanic ashes and lava.

The original work of the Geological Survey of Great Britain in this district, especially in the south of Wales, has been greatly extended and improved upon by the late Dr. Henry Hicks, to whom we are largely indebted for the elaboration of the several groups which make up the Cambrian system in that principality and for the description of their faunas. His classification from the base upward is as follows :--

Caerfai group, including the Olenellus zone.

Solva group : this by its fossils belongs to the Lower Paradoxides beds.

Menevian group : this also contains Lower Paradoxides species. the Upper Paradoxides fauna has not been definitely recognized in Wales.

Maentwrog group—Olenus fauna.

Ffestiniog group, with Lingulella Davisii, &c.

Dolgelly group, with Parabolina, Peltura, &c. The summit of this is equivalent to the Dictyonema shale of Sweden.

Tremadoc group ; this contains the genera Niobe and Asaphellus, and is equivalent to the Ceratopyge fauna of Sweden.*

These standards have already been applied to the Cambrian rocks in New Brunswick, where most of the faunas referred to above have been recovered and the lithological aspect of the strata in which they exist has been noted ; so that there was now a standard more accessible to the Canadian geologist, and comparatively close to the proposed field of exploration, and a district where lithological resemblances may be supposed to have a more definite value.

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The lithology of the New Brunswick Cambrian beds had been studied and described before any fauna except that of the Lower Paradoxides beds was known in them, so the terms used in designation the several groups of strata in this system in New Brunswick, are based on their lithological aspect. Hence we have the following :—

* Fauna of Olenellus zone in Wales. Geol. Mag., London, 1871, p. 21.

*Division 0.*

*a.* Red conglomerate.

*b.* Red and green sandy slates.

*Division 1.*

*a.* Coarse gray sandstone or quartzite.

*b.* Coarse gray sandy slate.

*c.* Fine gray and dark-gray slaty shales.

*d.* Fine black carbonaceous slaty shales.

The two last contain the Lower Paradoxides fauna of Sweden.

*Division 2.*

*a.* Dark-gray slates with seams of gray sandstone.

*b.* Coarse gray slates and gray flagstones.

*c.* Gray sandstones and coarse slates (Linguloid shells).

*Division 3.*

*a.* Dark gray finely laminated slates.

*b.* Black carbonaceous and dark gray slates, less fissile than the last.*

Two other divisions were described, but these were found to be repetitions of those of Division 3. When the faunas of Division 3 were studied the latter was found to contain a number of faunas which were designated by the additional letters *c.*, *d* and *e*, the two last mentioned being Ordovician.

Cape Breton Cambrian similar to that of New Brunswick.

After eliminating from the described rocks of the Cambrian areas in Cape Breton some which are Pre-Cambrian, it is not at all difficult to recognize this entire series of deposits in the Cambrian succession of that island. The known fossiliferous beds of the island were Upper Cambrian, and the others, by their position relative to these, represented the middle and lower part of the St. John series. The confirmation of this view suggested by the lithological appearance of the beds was obtained when the faunas were collected and studied.

The study of the faunas of the St. John group, begun in 1881, was not completed until twelve years thereafter, but as the palæontology unravelled itself, it was found to be in close accord with what had been determined as to the Cambrian succession in Europe.

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*Illustrations of the Fauna of the St. John Group. Trans. Roy. Soc. Can., vol. I., sec. iv., p. 88, 1882.

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Thus the following faunas of trilobites and graptolites were found in the St. John group, which comprises the Divisions 1, 2 and 3 indicated above.

*Division 1.*

*b.* Fauna of Protolenus (not known in Europe).

*c*, *d.* Various sub-faunas of the Lower Paradoxides beds.

*Division 2.*

No trilobite faunas were found.

*Division 3.*

*a.* Fauna of Parabolina.

*b.* Fauna of Peltura.

*c.* Fauna of Dictyonema (graptolite).

*d.* Fauna of Tetragraptus (graptolite) and the trilobite Cyclognathus.

The fauna of Protolenus, not known in Europe, is found in New Brunswick and Newfoundland, below Paradoxides, but the other faunas follow the same succession in Europe. It also became clear from these discoveries that the uppermost part of the St. John group was not Cambrian but Ordovician, or Lower Silurian, and that the recognizable Cambrian part terminated with the Dictyonema fauna, but included that of Protolenus.

The faunas of both *b* and *c* in Division 3 had already been found in Cape Breton, so there was a reasonable hope that, in the underlying part of the Cambrian in that island, the faunas of the corresponding portion of the St. John group would be found on further study of the field and this hope has in part been realized.

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As the faunas and the lithological succession of the several divisions of the St. John Group did not agree in all respects with the European Cambrian it was thought advisable in 1890 to give them local names, and hence: --

*Division 1*, in which the first characteristic Cambrian fauna was found was called *Acadian*,

*Division 2*, which is very fully developed in the city of St. John, was called *Johannian*, and

*Division 3*, whose faunas were first distinguished in Cape Breton, was named *Bretonian.**

*Trans. Roy. Soc. Can., vol. viii, sec. iv, p. 129, 1890.

These names are used in the following report.

Since the conclusion of his work on the St. John group, the writer has been engaged in studying and developing the faunas of the *Division 'O'* of the classification given in 1882 for the St. John Cambrian. This division proved to be of much greater importance than it appears to have in the St. John section, and its extension eastward was studied in connection with that of the St. John group. At the eastern end of the St. John basin of Cambrian rocks a full exposure of its measures was found, where it exhibited two divisions with a conglomerate bed between, but the few organisms obtained were not of a sufficiently high order to afford any definite means of comparison with the faunas of other countries. Considerable time was given to the examination of these measures in 1888, and it was then spoken of as the Basal series.*

Regional name Etcheminian for the oldest Cambrian sediment in New Brunswick and Newfoundland.

Observations on this part of the Cambrian system were continued in the island of Newfoundland, where it was found to contain fossils in better preservation and greater variety. The finding of a distinctive fauna in this group of beds in Newfoundland made it advisable to give it a distinctive name, as has been done with the several divisions of the St. John group, and it was called *Etcheminian*. The observations made during the past three seasons in Cape Breton have served greatly to enlarge our knowledge of this portion of the Cambrian.

It is proposed to describe the distribution and thickness of the several groups of Cambrian strata, above defined, as they appear in Cape Breton, but before doing so it will be desirable to refer to two other groups which underlie them, one of which, the Coldbrook, is closely connected with the Etcheminian. The other is an entirely different and much older series.

## PART I.—STRUCTURAL GEOLOGY.

### TERRANES REPRESENTED IN THE CAMBRIAN SYSTEM IN CAPE BRETON.

When the writer began the study of the Cambrian system in Cape Breton (represented on the geological map as Lower Silurian), he found that one series of rocks comprehended in the section coloured as Silurian, was remarkably like the 'Upper Series' of the Laurentian area near St. John. An examination of the exposures of these beds at Long

*Trans. Royal Soc. Can., vol. vii, sec. iv, p. 135, 1889.

island in St. Andrew's channel and at McLean point to the south-west of Long island (the west point of Barachois harbour) convinced him that this resemblance was not accidental, and that the series bore the same relation to the Cambrian that the resembling beds in St. John county, New Brunswick did. This conclusion was confirmed by observations on Indian brook, where similar rocks were found to bear the same relation to the effusives which underlie the Etcheminian.

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This series as seen on Long island consists of dark gray limestone with layers of calciferous schist, frequently alternating, and dolomitic limestone, having beds of dark gray to black silicious schist, also dark gray feldpathic schist. At McLean point the same limestones are seen in a much less altered condition, and on the road further south-west black flinty shales occur. Similar rocks occur at McSween brook. Other exposures of this series are met with at McLean brook, Shenacadie, where the section occurs described by Mr. Fletcher in the Report of Progress, 1876-77, page 431.

Beside their resemblance to the 'Upper Series' of the Laurentian in St. John county, this group is thought not to be Cambrian for the following reasons :—

1. No similar series has been met with by me in the Cambrian rocks of Cape Breton or elsewhere.
2. They are cut by granitic veins ; the Cambrian is not.
3. Similar rocks in the Indian Brook district have furnished pebbles to the Cambrian conglomerates.
4. These rocks are cut by red granite which has also furnished pebbles to the Cambrian conglomerates.

I conclude therefore that this group should be detached from the Cambrian, and should probably go with the George river limestones.

## THE CAMBRIAN SYSTEM.

### THE COLDBROOK TERRANE.

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The relation of this terrane to the Laurentian Upper Series be
and to the overlying sedimentary Cambrian, are well shown at L
island in St. Andrews' channel.

Here along the north-western shore of the island the co
between these effusive rocks and the metamorphic 'Upper Serie
visible. The lower layers of the Coldbrook are gray ash rocks,

or less vesicular and calcareous. Resting upon these ash rocks and seen on the road to the ferry, is a mass of red felsites, showing flow-lines, etc, some of which are quite ferruginous and rusty-looking. Above the red felsites are fine-grained dark-gray felsites which in turn support the gray grits and sandstones of the marine Cambrian.

The red felsites at the Ferry road dip S. 55° E. mag. $<30$-$40°$. Further east on the island, they dip in the same direction at a higher angle, and all along the eastern shore of the island the dip of the felsites conforms in a general way to that of the overlying Cambrian marine beds.

Break in range of Coldbrook effusives.

From the south-west end of Long island, across and beyond Barachois harbour, there is a break in the range of Coldbrook effusive rocks that borders the north side of the Barachois basin. This break is partly the space occupied by Barachois harbour and partly the ridge opposite Barachois pond, which is of Lower Carboniferous conglomerate and sandstone. But near the mouth of McLeod brook, which enters the head of this pond, the effusives again come into view. Here they consist of dark gray amygdaloidal diabase, holding cavities filled with calcite, and having intercalated beds of water-washed felsitic sand, containing small oval fragments of soft black slate. At one point the bedding has a dip of $<30°$.

There must be a profound fault here with a downthrow to the south, as the floor of the valley of McLeod brook is occupied by the dark-gray shales or slates of the Bretonian division of the St. John terrane.

The Coldbrook rocks were again found further up this valley, on the north side, where the Bourinot road crosses the ridge between the valley and St. Andrew's channel at Boisdale. On this road the crest of the ridge is of pre-Cambrian syenite or quartz-diorite, but where the road begins to descend towards the valley of McLeod brook, this is overlaid by dark-gray effusive rocks, some of them compact, with tabular crystals of feldspar, others more vesicular, with calcite in the cavities. A third variety shows pebbles of brown and red felsite in a dark feldspathic paste. At the southern edge of these effusives there is some purplish gray slate.

Coldbrook effusives along west side of Barachois basin.

A band of coarse-grained quartz-diorite then intervenes, separating the above effusives from another belt running along the brow of McLeod brook valley. These show dark-gray, somewhat purplish-weathering amygdaloid, having vesicles of calcspar, and are seen after

passing the corner of the Boisdale-Bourinot road. On this road they appear at intervals at several localities to the point where the road descends into the valley of McLeod brook.

Mr. Fletcher's report 1876-77, page 429, (last paragraph) would indicate that there is a considerable manifestation of these rocks and the over-lying conglomerates at the sources of McLeod brook and Indian brook which meet in the upper part of this valley.

For its whole length the Barachois Cambrian basin from George river station to the source of McLeod brook, is bordered on its southern side by a prominent ridge of Pre-Cambrian syenite. Southward of Long island ferry these rocks reach the water in Barachois harbour, and hence to the head of McLeod brook we see no Coldbrook or Etcheminian rocks on that side of the valley. At Barachois harbour flags and slates of the Johannian division of the St.John terrane lie along the base of the granite ridge, but from the harbour to the head of the valley of McLeod brook no rocks were seen but those of the Bretonian division of the same terrane. It may be inferred that there is a heavy fault along this side of the valley by which the Coldbrook and the overlying terranes have been depressed, and only the highest part of the Cambrian is visible along the base of this ridge in McLeod brook valley.

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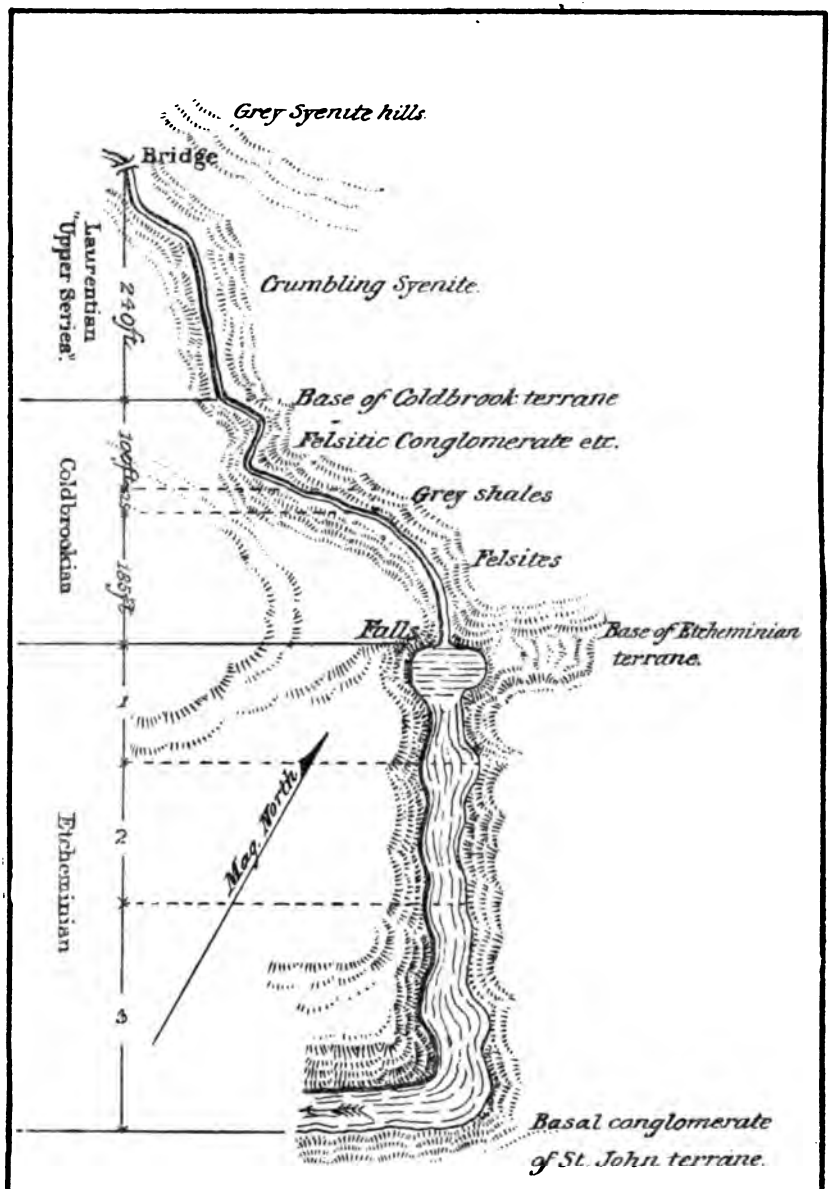
In the valley of Indian brook on East bay of the Bras d'Or lake, volcanic effusives intervene in the same way as in the valley of McLeod brook between the Laurentian 'Upper Series' and its intrusive rocks, and the marine Cambrian. They are seen on all the small brooks tributary to that stream, but are exposed in their entire thickness on Dugald brook. *(See map opposite.)*

Here the lower half consists of material more or less water-worn : for the most part a feldspathic sandstone with irregular layers of conglomerate. The latter have rounded pebbles, some of felsite and others of granite ; the conglomerates are not thoroughly water-worn and have a paste largely feldspathic. This half of the Coldbrook strata is capped by thirty feet of fine gray shale with fossils. These shales, in their slicken-sided surfaces and distorted fossils, give evidence of the greater disturbance and pressure applied here than to the Etcheminian shales of the next terrane above. Some layers have numerous though small phosphatic nodules.

The shales are succeeded by red and purple earthy felsites, and higher by purplish and purplish-gray amygdaloids. These felsites and amygdaloids seem to take the place in this section of the red felsites of




**GORGE OF DUGALD BROOK**

*Showing Coldbrook and Etcheminian terranes*

*Scale 200 feet to 1 inch*

Long island described above. Mr. Fletcher in the Report of Progress for 1876-77 at page 413 gives a section of the rocks on this stream.

ldbrook sites, &c. valley of ra river.

In the valley of the Mira river the Coldbrook terrane appears in great force. At McCodrum hill on the Morley road, one meets with much felsite breccia at the top of the hill and on the slope toward the Mira river. It consists of, first a dark gray, white-weathering felsite, then felsite of a brick-red colour whose fragments have been scattered by glacial action over the low lands of the Mira valley to the south.

On the opposite side of the Mira valley are extensive exposures of the Coldbrook effusives. Bengal settlement is located on these rocks and towards its eastern end at the road, there are considerable exposures of red breccia-grit having a purplish-red paste with imbedded angular fragments of gray felsite.

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The extent of these rocks south of the road was not ascertained, but they extend 200 yards north of the road, across the strike, and dip N. 30° W. mag. $< 60°$, and are overlain in that direction by greenish-gray, white weathering, and red-weathering schistose felsite, having a few small angular fragments of felsite imbedded, with the same dip as the breccia grit nearer the road. The upper felsites, 200 yards north of the Bengal road, would correspond to the red felsites of McCodrum hill in age, and are overlain by the next terrane, the Etcheminian, which, where its measures are exposed along the base of these effusives two miles to the west on the Bengal road, dips N. 50 W. mag. $< 80°$.

Mr. Fletcher's reports show that from the valley of the Mira river to the Atlantic coast, and along this coast from Scatari island to Forchu bay and Framboise, there is an extensive tract occupied by felsites and breccias, and it may be surmised that this was an important centre of eruption in Coldbrook time, such a centre as, in the province of New Brunswick, existed in the eastern part of St. John county. The great mass of diorites, felsites and amygdaloids forming the Quaco hills of that district have been described by Dr. L. W. Bailey in Report of Progress 1877–78, pages 10 DD. to 21 DD.,&c.

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The only place where this terrane was observed to be fossiliferous was at Dugald brook, a branch of Indian brook on East bay: the section on that brook is described in connection with the following terrane.

## THE ETCHEMINIAN TERRANE.

A long narrow basin of Cambrian rocks extends from George river station to the head of McLeod brook, past Barachois station and harbour

on St. Andrews channel. The Etcheminian terrane is exposed at the north-east end of this basin, but the structure is complicated by faults and folds.

At George river station is the north-eastern end of a long ridge of syenitic rocks which extend the whole length of the basin, bordering it on the south-eastern side. The basal conglomerates of the Etcheminian are wrapped around the north-eastern end of this ridge, and around the corresponding end of Long island. On this island, however, they rest on Coldbrook felsites and breccias, and no syenite is visible. In the railroad cuttings at George river station the contact of these conglomerates with the syenite can be seen at several places. They fill hollows in the syenite and dip N. mag. and N. 20° E. mag. $< 60°$. Felsite boulders are common in these conglomerates. Basal conglomerate of the Etcheminian in Barachois basin.

Westward of the station and beyond a brook and an embankment, the conglomerates are seen to rest on dark purplish-gray fine-grained felsite similar to those of Long island and presumably of the Coldbrook terrane; one bed has boulders six inches to two feet in diameter, of dark purplish-red felsite, some of which are quite siliceous. This is followed by fine-grained earthy felsite with crystals of kaolinized feldspar, showing ancient weathering. With these conglomerates is a hard purplish-red slate, and a compact feldspathic rock seamed with epidote. The dip here is N. 10° W. mag. $< 85°$; but the prevalent dip in the cutting is to the S.S.W.

Off the railroad track one hundred yards to the south-west is a mass of gray slate, etc., which would seem to be the upper division of the Etcheminian terrane. Here the railroad track begins to turn to the south, and after passing a space of about eight hundred feet, one comes to purplish-red slates and purplish-gray sandstones of the lower division of the Etcheminian. The cleavage planes here dip N. 55° E. mag. $< 90°$, but the dip of the beds is N. 5° W. mag. $< 50°$. The shaly layers below the sandstones have a few Lingulellas, not well preserved. These beds are capped by Lower Carboniferous limestone extending to the shore. Associated slates and sandstones.

At Young's brook just beyond this hill, these red slates and sandstones are cut off by a fault, and the rocks which appear to underlie them are gray. These show on the shore and along the railroad track and are the base of the upper division, which extends thence along the west side of the valley of Young's brook to the highway and beyond. The valley itself and its eastern side up to the syenite are occupied by dark-gray slates &c., a portion of the St. John terrane. The purplish coarse gray slates west of Young's brook in the railway cutting dip

S.E. mag. < 40° and have sandstone beds with much felsite sand, and with some pebbles of red felsite and of black siliceous slate. Elsewhere in this cutting the dip of the beds is S. 20° E. mag. < 60° and the hade or slope of the cleavage N. 70° W. mag. < 85°. These sandstones hold a Lingulella similar to *L. Selwyni.*

Westward of this on the railway there is a space of 1,100 feet without exposures, and thin cuttings in the same gray rocks where the dip is S. 50° W. mag. < 50°, and a little further, S. 20° W. mag. < 80°. These gray rocks continue along the railroad about 1,500 feet further, and are supposed to be about the middle of the Etcheminian. Passing up from Young's house across the railway to the road, one meets with ledges of gray, cream-weathering argillites which belong to the upper division of the Etcheminian. They extend from the school-house along the highway toward Barachois, and southwardly along the west side of the valley of Young's brook.

Along the shore of Long island passage at the foot of this ridge of argillites on the western side are dark-gray slates and gray flags of the St. John terrane.

A section in a south-east direction across the Cambrian basin from Young's point, on St. Andrews channel, for half a mile, to the syenite of the Boisdale hills would give the following succession :

tion.

500 feet red and gray slates and sandstones = Lower Etcheminian. The base of the terrane is concealed by the water of St. Andrews channel.

1,500 feet fine gray and some coarser argillites. Anticlinal in Upper Etcheminian.

300 feet in valley of Young's brook = Part of St. John group.

300 feet unexplored to border of syenite as given by Mr. Fletcher.

Returning to Young's house and the shore of St. Andrews channel in front of it, the red slates which were seen east of Young's brook are here well exposed in a low cliff along the shore. They are more fossiliferous here, and when not too strongly cleaved show well-preserved examples of Lingulella, especially *L. Selwyni.*

sils ed by . Fletcher.

Fossils were first observed by Mr. Fletcher, and subsequently by Messrs. Weston and Robert of the Survey staff, who were sent here to collect. It is not quite certain to me that they collected from Young point as their collections are marked McAfee point, and their specimens are larger than those I found, but the similarity of the fossils show they were from the same division of the Etcheminian. The collections made here by Messrs. Weston and Robert were some years ago placed in the writer's hands for study, and they appeared to

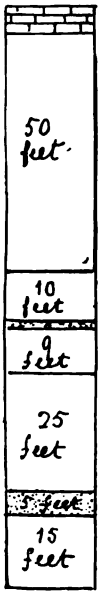
agree best with those of Lower Ordovician age, and so were considered to be of that system. The dips and strikes marked by Mr. Fletcher on his map appeared to agree with this view, as they showed a series parallel to the shore of St. Andrews channel, whereas the Cambrian beds in Long island passage exhibited a different strike. A personal visit to the locality has now convinced me that these beds, in place of being at the summit of the Cambrian, are towards its base, and are in fact of the lower division of the Etcheminian.

The fossiliferous series extends in a low cliff along the shore of St. Andrews channel from Young point nearly to the mouth of Young brook, the cliff falling to the level of the beach as it approaches that stream. As the section runs nearly on the strike of the beds, only a small part of the lower division is exposed. The highest beds seen come from beneath a mass of Lower Carboniferous limestone on Young point, and progressively show lower beds for a distance of 150 feet along the shore. There is no lack of fossils, but the cleavage being transverse to the bedding those in the slates are greatly obscured, but in the sandy beds they are less distorted. It is in the lower beds, including a bed of grit 2½ to 5 feet thick, that the greatest variety of fossils is found.

Section of Lower Etcheminian at Young point.

*Vertical section at Young point. Scale 40 feet to an inch.*

Lower Carboniferous limestone.




Sandy shales and sandstones, chiefly gray sandstone and purplish-gray slate, the former predominating. The sandstones have pebbles and nodules coated with hematite, vertical worm burrows, (Arenicolites and Monocraterion), and shells of Lingulella are scattered over the layers.

Purplish-gray sandy shale.

Sandy layer with Lingulella, &c.

Purplish-red shale with Lingulella, &c., and a cream-coloured layer of felsite sand.

Red sandy slate, with scattered Lingulella, sharply folded against the bed of grit.

Grit, gray above, purplish-red below. Pebbles of slate, felsite quartzite and black silicious slate. Lingulella common.

Purplish-red shale, colour deepened in the seams and cleavage planes by hematite. Lingulella common.

No lower beds than these could be determined.

The 25 feet bed of slate comes down to the waterline about 150 feet east of Young point and then borders the shore for some distance. The dip then changes and the lower slates and grit reappear and dip S. 70° W. mag. < 70°. Further on the dip is S. 30° W. mag. < 30°. Then after a space where there are no exposures, one comes to the gray flaggy beds above mentioned which appear also in the railway cuttings. Here the dip is S. 50° E. mag. < 70°.

The fossils from this shore are described in the Palæontological section of this report.

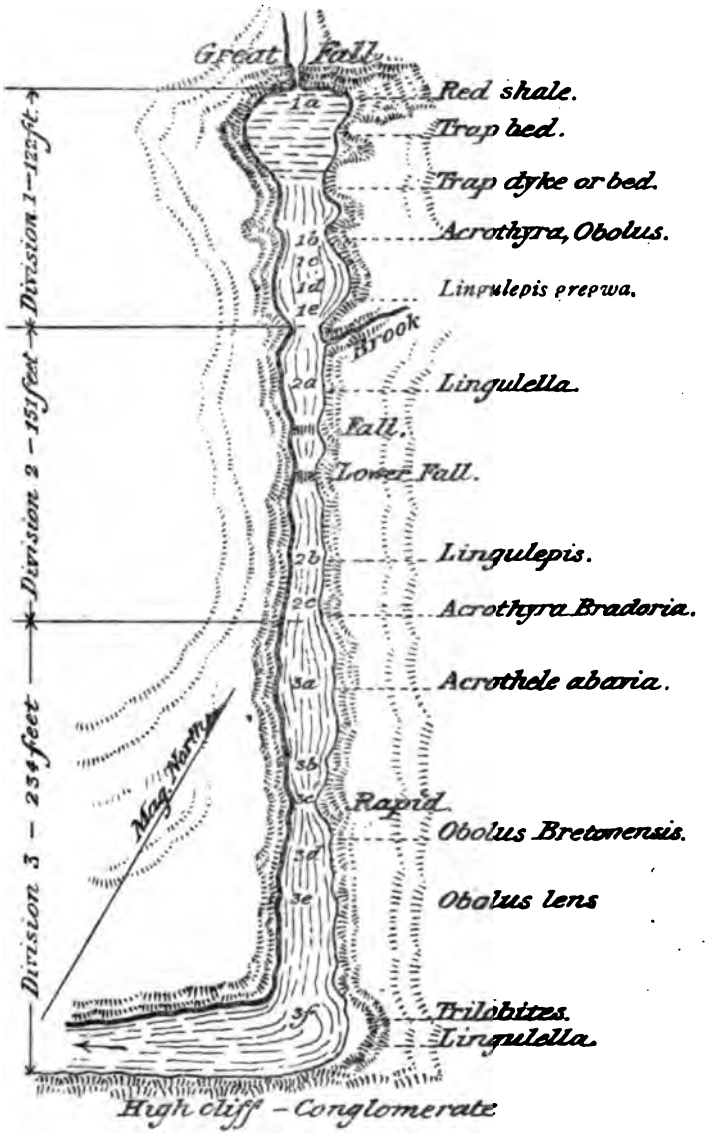
eminian
on on
e brook.

Exposures of what appear to be Etcheminian sediment are described by Mr. Fletcher as occurring on Steele brook, a small affluent of McLeod brook near its source. They are described at page 429 of the Report of Progress for 1876-7. Nos. 1, 4 and 7 have the characters of the strata of this part of the Cambrian system. On the supposition that the limestone and felsite are introduced into the Etcheminian rocks by faults, this reference of the numbers above quoted would be admissible. In connection with his description of the rocks of No. 3, of this section, Mr. Fletcher suggests the existence of a fault. This section would be unintelligible otherwise, as the natural position of the sandstones, if Etcheminian, is 1,000 feet or more below the black and gray shales of the bottom of the valley. These sandstones then appear to have been raised that distance above the St. John terrane, which fills the bottom of the valley.

:au of
brian
s in
an brook
y.

The basin of Cambrian rocks in the valley of Indian brook is just such a narrow trough as that of the Barachois basin, but the structure of the beds is entirely different. In the Barachois basin we trace an ascending series from the base of the Etcheminian at George river station to the head of McLeod brook, but on Indian brook the Cambrian rocks show an upward succession from the basal beds on the north-west side of the valley to the higher Cambrian beds on the south-east side. In this narrow valley the three terranes of the Cambrian stand on edge or as a series of vertical beds which form a plateau on the western side of the valley, while Indian brook runs in a deep and narrow trench along the eastern side. The valley is closed in on each side by higher plateaux of pre-Cambrian rocks consisting of crystalline limestones, felsites, various schists, and some beds of black flinty slates, the whole of the pre-Cambrian being cut, broken up and altered by great masses of intrusive syenite, also of pre-Cambrian age.

Owing to the elevation of the Cambrian plateau in this valley and the short courses of the brooks after they descend from the pr Cam-




**GORGE OF DUGALD BROOK**

*Showing the Etcheminian terrane*

*Scale 200 feet to 1 inch*

brian upland, most of them have cut deep gorges on their way to the main stream, and some good sections of the Cambrian rocks have been exposed. The best of these for the Coldbrook and Etcheminian terranes is that of Dugald brook. *(See preceding page.)*

ion on ald brook.

The Etcheminian terrane is exposed in the gorge below the falls at Dugald brook in a series of vertical beds from the base to the summit of the terrane. The measures are cut at right angles to their course which is N. 60° (mag.) and present the following upward succession.

DIVISION 1. In all 122 feet.

Assise *a* consists of

15 feet dark purple amygdaloid and bright red slate—Fossils.

10 feet dark purplish-gray trap and ash-rock.

18 feet soft purplish-red shale.

Assise *b* consists of

18 feet dark purplish-gray finely crystalline trap.

10 feet measures concealed (shales ?)

6 feet gray quartzites. Fossils in sand and clay seams at the top.

Assise *c* consists of

21 feet dark gray shale. Fossils at the middle of the assise, in soft layers.

Assise *d* consists of

21 feet compact dark gray sandy shale.

Assise *e* consists of

3 feet gray shale with seams of greenish-gray sand and lavender gray clay. Each of these assises is fossiliferous.

*Notes on the fossils of Division 1.*

Those of Assise *a* are found in the bright red shale. They are very much corroded and therefore obscure, a Hyolithes, a Lingulella and worm-burrows are recognisable.

ils of se *b* of sion 1.

ASSISE *b*.—The matrices of the fossils are seams of greenish gray-weathering sand, in layers of lavender gray, rusty-weathering fine shale. The grains of the sandy layers are mostly of pellucid and of green quartz. Some grains are of a bright copper-green colour. There are numerous minute fragments of red feldspar (and of red felsite?) not kaolinized. There is a pale green (magnesian?) deposit in places among the sand grains. The sand is mixed with numerous fragments of the shells of Brachiopods and a few Ostracods.

*Fossils—*

| | | | | |
|---|---|---|---|---|
| Acrothyra signata | ventrals | 7 | dorsals | 4 |
| Leptobolus? | " | 1 | " | 1 |
| Obolus triparilis | " | 3 | " | 4 |
| Lingulella longovalis | " | 2 | " | 1 |
| Lingulepis Gregwa? | (mould) | 1 | " | 0 |
| Bradorona spectator-acuta | right v. | 2 | left v. | 0 |
| B. ——— observator-lævis | " | 2 | " | 2 |
| Bradoria vigilans-obesa, &c. | " | 1 | " | 1 |

Assise *c*, its fossils.

Assise *c*.—The fossiliferous band in this assise is a fine gray to lavender gray shale, weathering pale brown in cracks.

*Fossils—*

| | | | | |
|---|---|---|---|---|
| Acrothyra signata-sera | ventral | 59 | dorsals | 53 |
| A. ——— ——— tarda | " | 6 | " | 4 |
| Obolus triparilis | " | 0 | " | 7 |
| Lingulella cf tumida | " | 0 | " | 1 |
| L. ——— longovalis | " | 1 | " | 0 |
| Lingulepis Gregwa | " | 0 | " | 5 |
| Hyolithes, wide apertural angle | | | tube | 2 |
| Orthotheca sp. | | | " | 2 |
| Bradorona perspicator-maxima | right v. | 1 | left v. | 0 |
| B. ——— spectator | " | 1 | " | 0 |
| Bradoria ornata | " | 1 | " | 0 |
| B. ——— vigilans, mut. | " | 1 | " | 1 |
| Crustacean, part of carapace | | | | 1 |

Assise *d*, its fossils.

Assise *d*.—The rock is a comparatively uniform mass of gray to brownish-gray shale, of uniform texture, somewhat charged with fine sand which consists largely of feldspathic particles. There are grains of a soft grass-green mineral and of kaolinized feldspar. *Lingulepis Gregwa* is scattered through a considerable thickness of this assise.

*Fossils—*

| | | | | |
|---|---|---|---|---|
| Acrothyra signata-tarda | ventral | 24 | dorsal | 27 |
| Acrotreta papillata | " | 2 | " | 1 |
| Lingulepis Gregwa | " | 42 | " | 38 |
| L. ——— ——— var | " | 5 | " | 5 |
| Orthotheca sp | | | tube | 2 |
| Bradorona spectator | right v. | 0 | left v. | 2 |
| B. ——— ——— acuta | " | 2 | " | 0 |

ıise *e*, fossils.

Assise *e*.—The fossils of this assise are contained in greenish-gray sand, alternating with layers of lavender-gray clay. The sand is mostly pellucid quartz, and there are diffused pale green particles and films, which may be glauconite or some magnesian silicate. There are also black grains and a few lumps of calcium phosphate. Some of the fossils are fragmentary.

*Fossils*—

| | | | | |
|---|---|---|---|---|
| Obolus discus..... | young 2, | ventral | 1 | dorsal 4 |
| Lingulella longovalis..... | " | 14 | " | 8 |
| L. ——— cf tumida.. ..... | " | 2 | " | 4 |
| Lingulepis Gregwa, var..... | " | 2 | " | 1 |
| Leptobolus sp..... | " | 1 | " | 2 |
| Orthotheca sp..... | | part of tube | | 1 |
| Hyolithes, sp..... | | | " | 1 |
| Bradorona spectator-spinosa.. | right v. 1, | | left v. | 1 |
| Indiana ovalis..... | " | 1, | " | 1 |

ıises of ision 2.

Division 2. 151 feet.

Assise *a* consists of

3 feet of gray fine-grained felsite-conglomerate and grit.

33 " dark purplish gray feldspathic sandstone with some slate conglomerate.

37 " same rock with beds of gray quartzite about the middle. The fossils are in the lower half of the assise.

Assise *b* consists of

57 feet dark purplish-gray feldspathic sandstone. Fossils are in the lower part of the assise.

Assise *c* consists of 21 feet of similar sandstones, with a bed of gray conglomerate holding pebbles of purplish-gray (and a few of red) felsite, with some of black flinty slate. Fossils at the top of the assise.

*Notes on the fossils of Division 2.*

Assise *a*.—Fossils are rare and poorly preserved in these coarse beds. Only a Lingulella was seen.

Assise *b*.—In the sandstones of this assise are abundant grains of non-kaolinized red feldspar. The rock is strongly cemented and has some small calcite veins: the cement is partly calcareous, but there is enough iron to give the rock a rusty-brown colour which weathers

There are pieces of black siliceous slate and small pebbles of quartz. The Brachiopods of this band are not much corroded and have their natural contours.

*Fossils*—

Fossils of Assise *b*.

| | | |
|---|---|---|
| Acrothyra signata-tarda..... | ventral 1 | dorsal 0 |
| Lingulepis longinervis..... | " 9 | " 9 |
| Orthotheca..... | | tube 1 |
| Bradorona perspicator-magna.. | right v. 2 | left v. 0 |

ASSISE *c*.—Fine grained greenish gray sandstone with purple cloudings carry the fossils.

*Fossils*—

| | |
|---|---|
| Acrothyra signata-orta..... | ventrals 3, dorsals 2 |
| Bradorona observator-lævis ... | right v. 2 left v. 0 |

DIVISION 3. 234 feet.

Assises of Division 3.

Assise *a* consists of

4 feet gray shale with abundant scales of hydro-mica.

50 " dark gray feldspathic sandstones, having seams of gray grit with felsite debris.

Assise *b* consists of

25 feet fine gray shale.

Assise *c* consists of

25 feet gray argillaceous sandstone.

Assise *d* consists of

30 feet dark gray, and some purplish-gray shale.

Assise *e* consists of

18 feet dark gray shale, the beds alternately harder and softer.

Assise *f* consists of

40 feet dark gray somewhat siliceous flaggy shales, with pale gray seams at intervals.

32 " dark gray, rather coarse shales.

10 " siliceous gray shale.

The fossils are mostly from the middle of this assise.

*Notes on the fossils, &c., of Division 3.*

ASSISE *a*.—The rock containing the fossils in this assise is a lavender-gray to pure gray shale, weathering yellowish in the cracks, and

Fossils of Assise *a*.

probably containing some carbonate of iron ; there is some fine felsite sand, and minute spangles of white mica.

*Fossils*—

| | | | | |
|---|---|---|---|---|
| Acrothyra proavia-prima.... | ventrals | 7, | dorsals | 10 |
| Acrothele abavia..... | " | 4 | " | 1 |
| Obolus Bretonensis..... | " | 1 | " | 0 |
| Lingulella sp..... ..... | " | 1 | " | 0 |
| Leptobolus sp..... | " | 0 | " | 1 |

ils of se *b.*

Assise *b.*—Purplish-gray shale with much diffused hematite, the rock giving a purplish-gray streak ; quite minute spangles of white mica are present. The fossils of this layer are much corroded, and do not show good surfaces.

*Fossils*—

| | | | | |
|---|---|---|---|---|
| Acrothele abavia..... | ventrals | 12 | dorsals | 21 |
| A——— avia ?..... | " | 1 | " | 1 |
| Obolus lens..... young 2, | " | 4 | " | 3 |
| Leptobolus atavus (long). . | " | 5 | " | 7 |
| Trilobite, sp..... | a pleura with a deep furrow | | | 1 |

ssise *c.*

Assise *c.*—The rock in which these fossils are embedded is a purplish-gray shale, with considerable diffused hematite and small spangles of silvery mica. The fossils are badly corroded, and the Leptoboli in consequence of the thinness of their shells are much distorted.

*Fossils*—

| | | | | |
|---|---|---|---|---|
| Acrotreta, sp ..... | ventral | 0, | dorsal | 1 |
| Actrothele abavia (on slab) ... | " | 4, | dorsal | 4 |
| Leptobolus collicia..... | " | 13 | | 15 |
| Lingulella, sp..... ..... . | " | 0 | | 1 |

ssise *d.*

Assise *d.*—The rock containing the fossils is a gray and purplish-gray shale, with very minute spangles of gray mica. *Obolus Bretonensis* is near the bottom of this assise.

*Fossils*—

| | | | | |
|---|---|---|---|---|
| Acrothele avia..... ..... | ventral | 5, | dorsal | 7 |
| Obolus Bretonensis.... young, 1, | " | 6, | " | 4 |
| Leptobolus atavus ..... | " | 32. | " | 33 |
| Bradorona spectator-æquat..... | right v. 1, left v. 2. | | | |

ASSISE *e*.—Gray shale with flaggy layers, the lamination due to seams covered with shells, alternating with others where the shells are scarce. The rock has spangles of silvery gray mica. Of Assise *e*.

*Fossils*—

| | | | | | |
|---|---|---|---|---|---|
| Acrothyra proavia..... | ventrals | 160, | dorsals | 160 |
| A—-—— ——— crassa | " | 1 | " | 0 |
| Acrothele avia.... .... | " | 9 | " | 10 |
| A-—-——— abavia..... | " | 5 | " | 0 |
| Obolus lens..... | " | 17 | " | 16 |
| O—— lens-longus..... | " | 3 | " | 1 |
| Leptobolus collicia..... | " | 18 | " | 26 |
| L—-—-—— atavus ..... | " | 69 | " | 63 |
| Lingulella, sp..... | " | 0 | " | 1 |
| Indiana ovalis..... | right v. | 1 | left v. | 1 |
| Bradorona scrutator.... | " | 3 | " | 1 |
| B———observator-ligata. | " | 2 | " | 2 |
| Bradoria vigilans. ..... | " | 6 | " | 2 |
| B——— rugulosa..... | " | 5 | " | 3 |
| Schmidtella? pervetus... | " | 2 | " | 1 |
| S————? acuta..... | " | 3 | " | 3 |

ASSISE *f*.—The rock containing the fossils is a gray shale, more sandy than that of assise *e*. Some of the layers have a purplish tinge, and the spangles of silvery mica that occur are larger than those of the assise below. The highest band of these shales is quite silicious. Of Assise *f*.

*Fossils*—

| | | | | |
|---|---|---|---|---|
| Acrothyra proavia-prima?..... | ventral | 1, | dorsal | 0 |
| A—— ——crassa?..... | " | 1 | " | 0 |
| Acrothele proles..... | " | 23 | " | 12 |
| L———-— collicia..... | " | 6 | " | 2 |
| Leptobolus collicia collis. ..... | " | 21 | " | 16 |
| L———-—— atavus..... ... | " | 0 | " | 1 |
| Bradorona perspicator-major.... | right v. | 1 | left v | 1 |
| B——— scrutator..... | " | 0 | " | 1 |
| Solenopleura (?) Bretonensis part | | | | 2 |

At the top of this assise the Etcheminian terrane is overlain by a body of felsite conglomerate, which rises in a wall-like mass one hundred feet or more in height, and turns the course of the stream westward.

Conglomerate at the base of St. John group.

Further down stream it is seen that this conglomerate, which is regarded as the base of the St. John terrane, has a thickness of thirty

feet, and contains partly rounded pebbles of felsite in a felsitic paste. It is followed by dark gray feldspathic amydgaloid and dark gray porphyritic greenstone.

About half a mile north-east of Dugald brook a traverse was made across the Cambrian plateau. Except some purplish-gray sandstones at the foot of the syenite hill, there are no exposures for 925 feet. There is then a rising slope of 150 feet showing some exposures of the Upper Etcheminian shales. Then ninety feet to a ridge of felsite-breccia with seams of gray shale; this seems to be the equivalent of the basal conglomerate of the St. John terrane seen in the gorge at Dugald brook. Following this, in a space of seventy-five feet, there is a ridge of dark gray ash-grit with a paste of a partly gray to dark gray felsitic sand, partly a conglomerate with felsite pebbles, one inch across. The dip here is S. 20° E. mag. $<70°$. This also is a part of the St. John terrane.

In this section the Coldbrook and Etcheminian terranes occupy a a quarter more space than they do at Dugald brook, where, however, they are vertical.

ction on oundary ook.

The small brook at the boundary of the Indian reservation of Escasonie on its eastern side, affords a somewhat interrupted section that throws additional light on the relation of the Etcheminian to the St. John terrane. As at the former brook, the base of the Cambrian rests against pre-Cambrian schists and intrusive rocks. The lowest bed noticed was a reddish quartzite, not measured, but having a thickness of about thirty feet.

| | | |
|---|---|---|
| Assise *a* | 30 | feet reddish-gray quartzites. |
| | 30 | " soft red sandstone, full of quartz veins and fragments of feldspar. |
| Assise *b* | 35 | " dark purplish-gray felsite-conglomerate. It forms a ridge broken through by the brook |
| Assise *c* | 25 | " lower part, purplish-gray felsite shale. Ostracods and small Brachiopods occur, but they are rare. |
| Assise *d* | 20 | " purplish-gray sandy shale. Fossils abundant. |
| | 25 | " dark gray shale, *Lingulepis Geeyæ* common |
| Assise *e* | 25 | " no exposures to the bridge at the road. |
| | 190 | Division 1 of the Etcheminian |

| | |
|---|---|
| 150 feet. | No exposures on the brook, but a smallt ributary coming in from the east, on the line of strike has purplish-red sandstones of Division 2. |
| 100 feet. | No exposures except at the top where there are dark purplish-gray sandstones with veins and seams of hematite. |
| 250 | Division 2 of the Etcheminian. |

| | |
|---|---|
| 15 feet | gray argillite or shale. |
| 30 " | measures concealed. |
| 15 " | felsite conglomerate, with fragments of black silicious slate. |
| 50 " | gray sandstones, flags and slates. |
| 110 | Division 3 of the Etcheminian. |

This section shows a thickening of the two lower divisions of the Etcheminian, but the upper division is greatly reduced in bulk, perhaps by erosion prior to the deposition of the St. John terrane. The beds of Division 1 are correlated with those of Dugald brook, partly by lithological resemblances, and partly by their fossil contents. Collections were made from Assise *d*, of Division 1, and the following fossils determined:—

Fossils of Assise *d* of Division 1 on Boundary brook.

*Fossils:*

| | | | | |
|---|---|---|---|---|
| Acrotreta papillata..... | ventrals | 25, | dorsals | 24 |
| Obolus sp..... | " | 2 | " | 0 |
| Leptobolus cf atavus..... | " | 5 | " | 3 |
| L——— cf. collicia..... | " | 3 | " | 1 |
| Lingulepis Gregwa...yng | 8, ventrals | 40, | dorsals | 44 |
| L———sp..... | " | 5 | " | 3 |
| Orthotheca sp., broken tube | | | | 2 |
| Bradorona perspicator, right v. | 2, left v. | | | 2 |
| Bradorona spectator.. | " | 5 | " | 9 |
| B——— observator. | " | 4 | " | 8 |
| B——— ——— benepuncta, right v. | 3, left v. | | | 2 |
| Bradoria vigilans, mut..... | " | 1 | " | 0 |
| Escasona rutellum-prima.. . | " | 0 | " | 1 |
| Schmidtella (?) pervetus-concinna | " | 0 | " | 1 |

posed
sion of the
per
cheminian.

It is assumed above that the upper division of the Etcheminian ends at the great conglomerate named below. If, however, the lower conglomerate, 15 feet, (named above) be taken as the base of the St. John group (there are three conglomerates in it on McMullin brook), there are only 45 feet of measures of the Upper Etcheminian at Boundary brook, whereas on Dugald brook there are 230 feet. At Vincent McPhee's farm, half a mile north-east of Boundary brook, the Upper Etcheminian is 120 feet thick. The nature of the Upper Etcheminian sediments is such as to make it improbable that the great differences in the bulk of this member can be due to variation in its original thickness. It is more likely to be due to erosion of this division before the deposition of the St. John group, or to faults that have cut out a great part of this member of the series.

adian divi-
n of the St.
n group.

70 feet felsite conglomerate, with pebbles of felsite, &c.

20 feet gray ochrous-weathering clay slate. Impressions of seaweeds in lower part.

20 feet hard compact gray slate.

20 feet measures concealed.

20 feet light buff felsite conglomerate with ochrous spots.

40 feet measures concealed.

40 feet gray flags and sandy slates, followed by gray flags and quartzites.

---

230 The Acadian division of the St. John group would come into this part of the section.

==

annian
ision of
s group.

50 feet gray felsite-conglomerate.

40 feet gray slate and quartzite.

60 feet measures concealed.

30 feet channel of Indian brook.

---

180 Part of the Johannian division.

==

This last portion of this section may be assigned to the Johannian division of the St. John group, but it is obviously only a small portion of this division. Possibly the eighty feet (40 + 40) here assigned to the Acadian division should be transferred to the Johannian.

Section of Cambrian on Gregwa brook.

Westward of Boundary brook, a large stream called Gregwa brook, runs across the Indian reservation. In its lower course it is cut down nearly to the level of Indian brook, of which it is a tributary, and so does not give continuous exposures. In going up the stream the first ledges met with are the felsite-conglomerates of the Acadian division of the St. John group. The intervening flags and slates, being softer, are not exposed. A fine-grained slate appears further up stream in which no fossils were found, and beyond this, in the banks and channel, gray shales occur. These shales contain *Obolus Bretonensis* and an Acrothele and therefore are assigned to Assise *d* of the Upper Etcheminian. The valley here is narrowed by abrupt hills, which consist of purplish-gray feldspathic sandstones, rich in iron, as they contain fahlbands of hematite. These sandstones belong to Division 2 of the Etcheminian terrane.

Upper and Middle Etcheminian.

Lower division of the same and the Coldbrook terrane.

Above this, on the east branch of this brook, are some exposures of gray rusty-weathering shales, holding the place of Assises *c*, *d* and *e* of the lower division of the Etcheminian terrane. Further up the brook are purplish-red schist and sandstone that hold the place of Assises *a* and *b* of this division. They dip N. 30° W. mag. < 70. Here the section passes to the gray amygdaloids and feldspathic rocks of the Coldbrook terrane, over which this branch falls in cascades to the valley below. Above the falls these effusives continue for a short space and show purplish-red felsite rock, porphyritic and amygdaloidal. There is no great body of these effusives. On the main or west branch of Gregwa brook a similar succession is found. Here the lowest Etcheminian beds seen correspond to Assises *a* and *b* of Division 1, and consist of dark-red, crumbling calciferous conglomerate; this passes into a dark-red sandstone, and is succeeded by red, and then gray quartzites in massive beds.

Section of Cambrian at Gillis' brook in the upper part of Indian brook valley.

An examination was made of the Etcheminian and St. John terranes at Gillis brook, a branch of Indian brook, to near its source, for comparison with the section of Dugald brook. This section is about two and a half miles north-east of Dugald brook. There are two branches of this brook, of which the western comes down from a granite hill to the north of Gillis house, and the eastern comes from lower land to the eastward, but traverses the same terranes as the western branch.

Where the western branch comes off the granite hill, a thin body of amygdaloidal ash-rock is all there is to represent the Coldbrook terrane. Resting on this is a narrow ridge of pink quartzites, upon which lie some beds of purplish-red sandstones. South of these there is a space where the measures are concealed, and following this the felsite breccia-

conglomerate that marks the base of the St. John terrane. The space between the granite and this conglomerate, measured by my assistant, was two hundred feet. The indications are that the whole three divisions of the Etcheminian are represented in this space as well as the Coldbrook terrane, and it appears to be a case of scant deposition, such as marks some of the valleys holding Cambrian deposits in New Brunswick.

The Etcheminian measures, which are out of sight in this section, appear on the eastern branch of Gillis brook where they occupy the bed of the stream with the breccia-conglomerate (of the St. John terrane) on the south and the purplish-red sandstones and pink quartzites to the north. The breccia-conglomerate here is full of fragments of felsite, and of the red granite which appears in the hill to the north, and there are a few fragments of black silicious slate, all of which are found as rock masses, either in the Coldbrook terrane, or in the adjoining pre-Cambrian complex.

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an brook.

On the east branch of Gillis brook, where the beds of Division 3 are exposed beside the breccia-conglomerate, they contain various fossils, as *Acrothyra proavia-crassa*, *Acrothele proles*, *A. avia-puteis*, *Leptobolus collicia*, *Leptobolus collis*, *Bradorona scrutator*, a trilobite, *Solenopleura* (?), &c. Between the ridge of breccia-conglomerate behind Gillis house and the deep valley of Indian brook, the land descends rapidly, and there are a few exposures of the gray flags and slates of the Johannian division of the St. John terrane; the space to Indian brook is about 2000 feet.

THICKNESS OF THE ETCHEMINIAN IN THE VALLEY OF THE MIRA RIVER.

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In this valley I could not find the breccia-conglomerate, which on East bay so distinctly marks the upper limit of the Etcheminian terrane. The top of this group and the base of the St. John group in the Mira valley each consists of soft and fine sediments, and from the erosion of these beds the contact between the two terranes is seldom seen. Their colour and relation to the overlying mass of flags and quartzites of the Johannian division of the St. John group will often serve to distinguish them. The slates of the Acadian division of the St. John group in this valley are dark gray (often purplish-gray weathering); those of the upper division of the Etcheminian are compact pale gray (often greenish-gray weathering); there are also purplish-red slates in this division, while only pure gray, or faintly purplish beds are known in the St. John group.

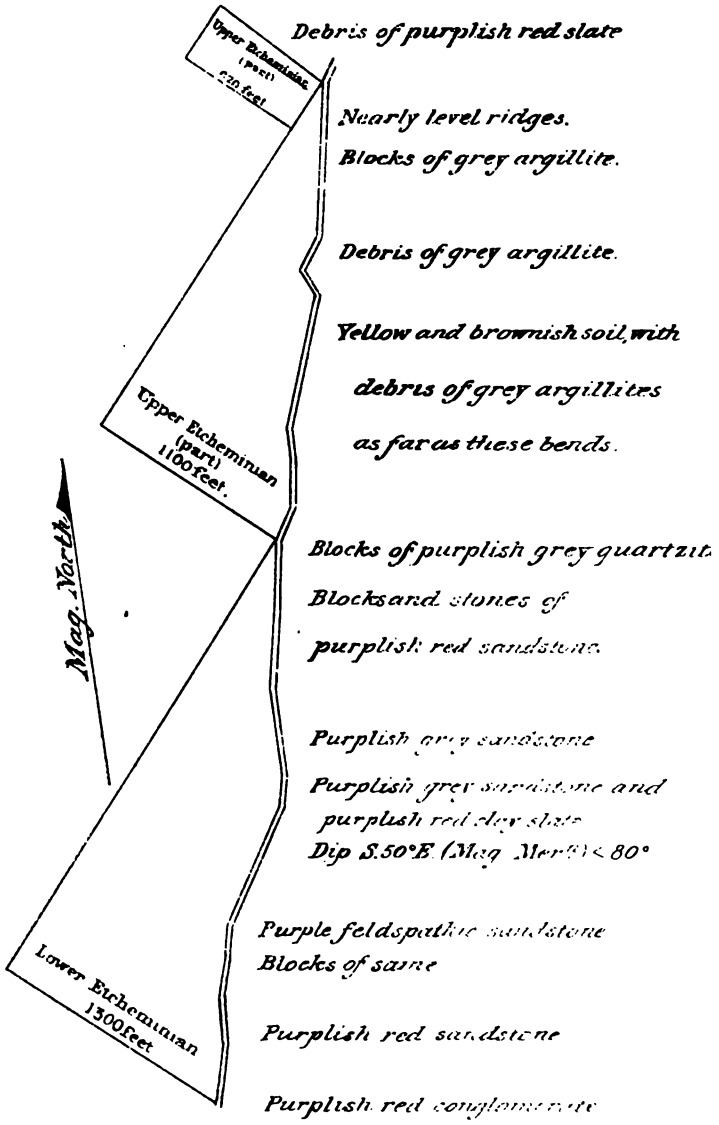
A section was examined some years ago by Mr. Hugh Fletcher, who found in the gorge at the old mill at McCodrum brook the following measures:— Section on McCodrum brook.

| | Feet. |
|---|---|
| 1. Reddish, fine, coherent micaceous sandstone | 16 |
| 2. White quartzite, or grit, in which the grains are scarcely distinguishable. It passes into white quartzose conglomerate..... | 10 |
| 3. Purple, pebbly, close-grained quartzose grit, passing, lower down the brook, into reddish conglomerate with pebbles as large as hazel nuts. Dip, N. 76° E. < 30°.... | 1 |
| 4. Greenish-gray, soft somewhat soapy and flaggy argillite. Dip. N. 53° E. < 29°... | 59 |
| 5. Greenish, nearly compact micaceous sandstone, slaty or in even flaggy beds. It forms curious gorges and falls, being cut on the strike for a great distance, so that the angle of dip is the slope of the right bank of the brook. Dip. N. 50° E. < 33°. | 540 |
| | 626 |

In quoting this section I have reversed Mr. Fletcher's numbers. His record of dips on the lower part of the brook south of this section shows that the Etcheminian here is mantling around the felsite hill, 'McCodrum mountain,' and the lower part of the lower division of the Etcheminian is thin. Nos. 1, 2 and 3 correspond to the assises *a* and *b* of the lower division, and No. 4 to the assises *c*, *d* and *e*. *Lingulepis Gregwa* and other brachiopods, not well preserved, are found in the slates on McCodrum brook. No. 5 is chiefly the middle division of the Etcheminian, of a grayer colour than in Indian Brook valley.

The beds at the contact of Nos. 3 and 4 have seams of red and pale yellow ochre. They are finer than the corresponding shales on Dugald Brook.

On the west side of the Mira valley we found no exposures that would exhibit a continuous section of the Etcheminian terrane, nor on the east side were there any such; but on this side, exposures of ledges along the roads and streams and the surface soil show that the group is well developed.


Upper Etcheminian (part) 250 feet
Debris of purplish red slate
Nearly level ridges.
Blocks of grey argillite.
Debris of grey argillite.
Yellow and brownish soil, with
debris of grey argillites
as far as these bends.
Upper Etcheminian (part) 1100 feet.
Mag. North
Blocks of purplish grey quartzite
Blocks and stones of
purplish red sandstone.
Purplish grey sandstone
Purplish grey sandstone and
purplish red clay slate
Dip S.50°E (Mag Mer[illegible]) < 80°
Purple feldspathic sandstone
Blocks of same
Lower Etcheminian 1300 feet
Purplish red sandstone
Purplish red conglomerate
Dip N.50°W (Mag Mer[illegible]) < 80° to 9[illegible]

ETCHEMINIAN TERRANE, W. BENGAL BC

Scale 1000 feet to one inch

*(See map opposite.)*

Traverse on West Bengal road.

On the West Bengal road the contact of this terrane with the effusive rocks of the Coldbrook is seen a short distance north of A. McDonald's, where a heavy conglomerate with pebbles of quartz and felsite crosses the road in vertical beds. For about half way to the corner of this road and the Trout brook road at Johnson's, purplish-red sandstone in blocks or ledges indicates the presence of the Lower Etcheminian (Divisions 1 and 2). A quartzite ledge marks the passage to the Upper Division. The thickness of the Lower Etcheminian here is estimated at 1,300 feet. In the two-thirds of this there is much hard purplish-gray feldspathic sandstone and slate, weathering lavender gray.

Upper division of Etcheminian.

For another half mile the road runs diagonally across a low ridge, where, from the soil exposed and the ledges and blocks visible, it may be inferred that the upper division of the Etcheminian terrane is present. From the known strike of the argillites visible here, it is estimated that there are 1,100 feet in width of measures of the pale gray argillites. There is also north of the road, at Johnson's, 600 feet in width of a swale filled with debris of purplish-red slates, which appears to be of the same terrane. Such strata were not seen in the Cambrian basins of East bay and St. Andrews channel to the northwest. With this addition there are 1,700 feet of Upper Etcheminian rocks on this side of the Mira valley at West Bengal road.

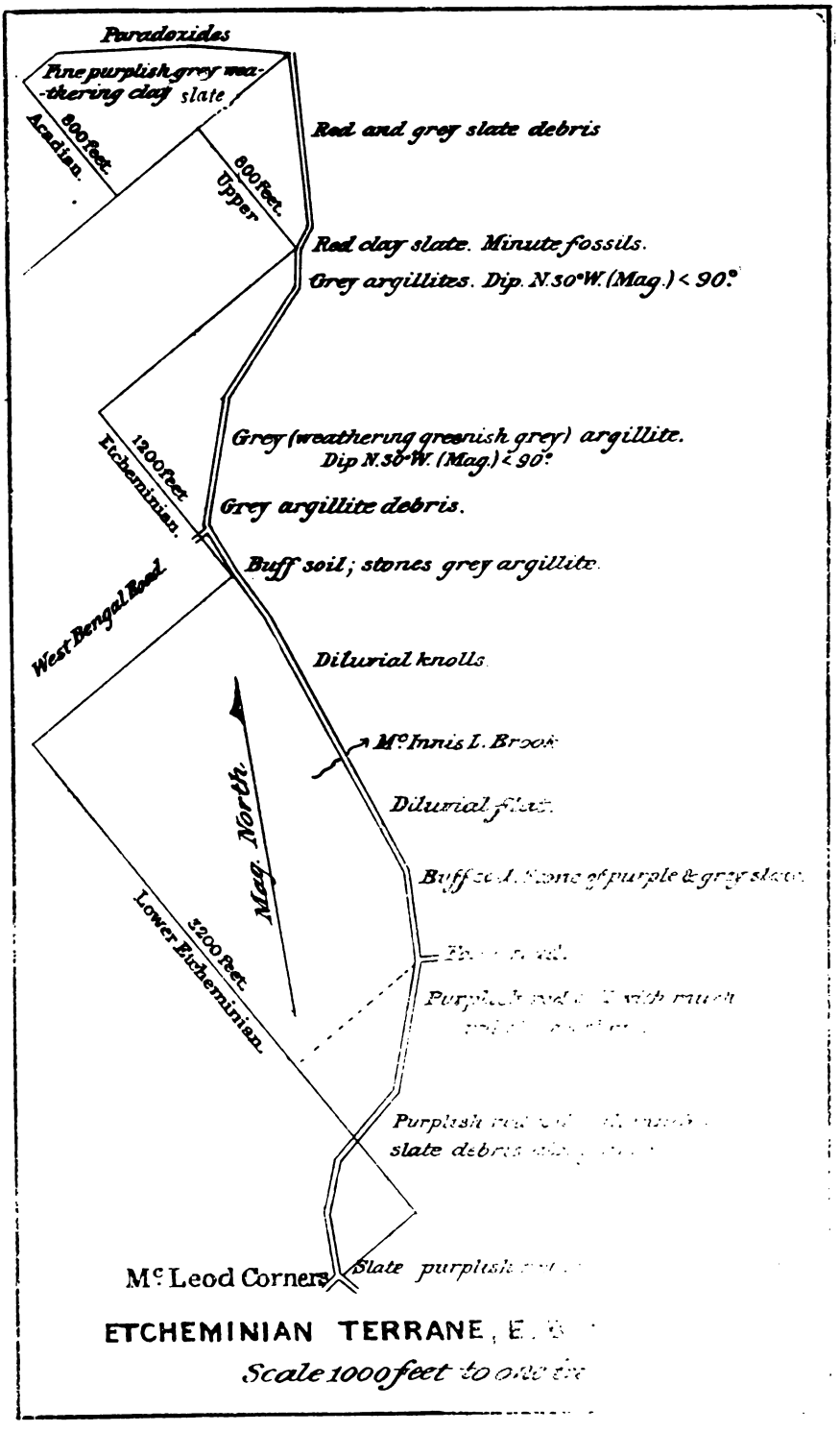
Thickness in two areas compared.

A comparison will show, if the thickness has not been increased by faults, how much thicker the Etcheminian is here than in the Indian brook valley.

| | Dugald Brook. Feet. | | Bengal Road. Feet. |
|---|---|---|---|
| Division 1..... | 120 | .... | 400 |
| " 2..... | 150 | .... | 900 |
| " 3..... ..... | 230 | .... | 1,100 |
| Additional measures..... | ... | .... | 600 |
| | 500 | | 3,000 |

THICKNESS ON THE EAST BRANCH OF THE BENGAL ROAD.

Another traverse of the Etcheminian was made on the north part of the Bengal road and its eastern branch leading to Bengal settlement. Here to the east of McInnis lake, the soil and some ledges show a width of 1,200 feet occupied by the measures of the lower division, or for a distance along the road of 2,000 feet. For an equal distance


Paradoxides
Fine purplish grey weathering clay slate
800 Feet.
Acadian.
800 Feet.
Upper
Red and grey slate debris
Red clay slate. Minute fossils.
Grey argillites. Dip. N.30°W. (Mag.) < 90°
1200 Feet
Etcheminian.
Grey (weathering greenish grey) argillite.
Dip N.30°W. (Mag.) < 90°
Grey argillite debris.
Buff soil; stones grey argillite.
West Bengal Road
Diluvial knolls.
Mc Innis L. Brook
Diluvial flats.
Mag. North.
3200 Feet
Lower Etcheminian.
Mc Leod Corners
ETCHEMINIAN TERRANE, E.
Scale 1000 feet to one inch

along the road and at right angles to the strike, no ledges are exposed where the road crosses the valley in which McInnis lake lies. This valley is filled with modified drift.

On the ridge north of this valley, however, where the West Bengal road branches off, there is a breadth of 1,200 feet of nearly vertical argillites of the Upper Etcheminian; and north of these, in a swale, 800 feet of red and purplish-gray argillite, of the supposed additional member at the top of the Etcheminian. Comparing this section with the one on the west branch of the Bengal road the following proportions appear:— Traverse on East Bengal road.

| | West Bengal Road. | | East Bengal Road. |
|---|---|---|---|
| | Feet. | | Feet. |
| Division 1..... | 400 | .... | 1,200 |
| " 2..... | 900 | .... | 2,000 |
| " 3..... | 1,100 | .. . | 1,200 |
| Upper red argillites | 600 | .... | 800 |
| | 3,000 | | 5,200 |

Above the upper red slates a mass of fine dark gray (purplish-gray weathering) clay slates is exposed for a width of 800 feet. As these contain species of the Paradoxides fauna they are to be assigned to the Acadian division of the St. John group.

### THICKNESS OF THE ETCHEMINIAN ON THE BOSTON ROAD.

*(See map on opposite page.)*

On this road the Cambrian rocks are mostly concealed by glacial debris or by woodlands. Coming down off the ridge of Coldbrook effusives in the Bengal settlement, at a point about two miles and a half north-east of the preceding section, the presence of basal beds of the Etcheminian is recognizable in a red soil, full of fragments of purplish-red sandstone. This soil continues to the stream draining the valley in which McInnis lake lies, and up the slope on the north side of this valley. The space across this valley is about 2,000 feet. Traverse of Etcheminian on Boston road.

The ridge on the north side of the valley is covered by a gray (buff-weathering) soil filled with stones and blocks of the gray argillites of the Upper Etcheminian. This surface covering has a width on this road of about 1,000 feet. After passing a wooded tract going towards the Mira river, the soil is found to be filled with fragments of the gray flags and slates of the middle part of the St. John terrane.

The width of the Etcheminian terrane along this side of the Mira valley for a distance of four miles on the strike is, at the

West Bengal road, 3,000 feet;

East Bengal road, 5,000 feet;

Boston road, 4,000 feet.

On the East Bengal road the bulk is increased by repetition of a part or all of the Lower Etcheminian.

### WITDTH OF THE ETCHEMINIAN ON THE SYDNEY AND LOUISBURG ROAD.

ide tract of cheminian Sydney d Louis- rg roads.

Mr. Fletcher gives data in his report which enable us to form an estimate of the extent to which the Etcheminian is spread out in the lower part of the Mira valley. He speaks of many outcrops of red and gray argillites, &c., along the Sydney and the old Louisburg road, from which it would seem that a width of two miles from a point near the Albert bridge to the McMillan lakes is occupied by Etcheminian rocks. And from these roads eastward to Mira gut, his descriptions would show that the country, coloured as Silurian (*i.e.*, Cambrian) is occupied by the Etcheminian terrane.

### OTHER AREAS OCCUPIED BY ETCHEMINIAN ROCKS.

cheminian ks around head of ra river.

There are other considerable areas coloured by Mr. Fletcher as Silurian (*i.e.* Cambrian) that are to be assigned to the Etcheminian terrane. Where he speaks of red and green argillites, or sandstones, or of conglomerates with felsite stones and grains, in the valley of the Mira river, it is reasonably sure that the rocks belong to the Etcheminian terrane. No rocks of the St. John terrane are indicated by these names, as all these are gray of various shades, from pale gray to almost black, or with a pale purplish tinge, and as a rule, they are more fossiliferous.

South of the ridge of effusive and intrusive rocks that bound the Mira valley on the south and east are outliers of stratified rocks which, from Mr. Fletcher's descriptions, appear to be Etcheminian. They are conglomerates with some greenish-gray argillites. Mr. Fletcher's description of the rocks on Canoe and Easg brooks, indicates that a belt of Etcheminian sediments extends from the Bengal road along the valleys of these brooks to the head of the Mira river above Victoria bridge.

At the head of the Mira river on its western side is a considerable stream in the valley of which are Etcheminian deposits, judging from

the kind of rocks which Mr. Fletcher says occur there. This stream is McDougald brook, (Kelvin Brook of the Geological Survey map). The rocks on this stream are described in the Report of Progress 1877–78 page 15 F. The large area of Etcheminian at the source of the Mira river and along the eastern side of its basin, as well as the great thickness they attain in this district, would indicate that they are near the main source of supply of sedimentary matter available for the building up of a geological terrane at that epoch. This source is to be looked for in the extensive deposits of Coldbrook effusives and to ancient erosion of the pre-Cambrian crystalline rocks that intervene between the Mira valley and the Atlantic ocean.

Source of the Etcheminian sediments.

## ST. JOHN TERRANE.

### *Acadian Division.*

The disturbed and complicated structure of the Cambrian terranes in the north-eastern end of the Barachois basin makes it difficult to recognize the Acadian division here by its lithological features, and no fossils characteristic of the division have been found. There are, however, two places where fine, dark gray slates occur. One is on the road from George river station to the Barachois; another is on the Intercolonial railway, south-west of Young's farm. At the first locality there are dark gray silicious slates a short distance from George river station. They lie between the road and the syenite hill to the east and dip N. 50° W. mag. < 45°. They are overlain in the valley of Young brook by flags and slates of the Johannian division. The other exposure of the slates of the Acadian division is along the track of the railway as mentioned above, some distance south of Young's house, at the foot of a slope of Etcheminian slates. This band of Acadian slates runs diagonally up the hillside and crosses the highway from George river station to Barachois. The rocks of this division in the Indian brook valley are described in connection with the next division of the St. John group.

Slates of the Acadian division in the Barochois basin.

On the east side of the Mira valley the Acadian division forms an important part of the St. John terrane, and contains characteristic fossils. The rock there is a dark gray (purplish-gray weathering) clay-slate, showing on the Bengal road. It contains lentiles or irregular layers of carbonate of lime, in one of which a Paradoxides, resembling *P. rugulosus*, a Ptychoparia, and a Palæacmæa (or Parmophorella) were found. A considerable thickness of these measures also exists on the west side of the Mira valley as seen at McLean brook near

Acadian slates east of the Mira river, and fossils.

Marion bridge. Certain dark gray clay slates, which, by their position appear to be of this division of the St. John terrane come in at the head of the Mira river. They are seen where the road crosses Canoe brook; on the west side of the Mira river also, about three-quarters of a mile south of the lime-kiln on the road near Salmon river, dark gray shales, of this age occur. At the latter place the shales contain Agnosti and some other fossils. It is probable that a belt of these slates runs along the eastern flank of the 'Big Ridge,' on the east side of the Mira river, connecting the outcrops on the Bengal road with those near the mouth of Canoe brook.

### *Johannian Division.*

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ıg island
ıage.

Except a narrow band in the valley of Young brook near George river station, this group is first seen at the western point of a little cove inside of Young point, at the eastern end of the Long island passage. A quite low cliff here consists of flaggy sandstones with some thin beds of dark gray shale. They dip S.E. mag. $< 30°$. There are layers covered with trails of Ctenichnites, burrows of Monocraterion and trails and casts of worms; also small, poorly preserved Lingulellas and an Obolus. Between the Acadian beds and these are some heavy beds of dark gray sandstone or quartzite.

Faulted in along the border of the Coldbrook felsites on the south-eastern side of Long island and at the south-western end of the island are certain conglomerates and sandstones of Cambrian age. On the south-east side of the ferry these sandstones dip S. 30° E. mag. $< 80°$, and have ripple-marks and burrows of Arenicolites, &c. At the end of the island the flaggy layers also show the pits and galleries of Arenicolites, and dip S. mag. $< 50°$. The conglomerates contain pebbles and boulders of weathered gray felsite, pale green slaty felsite, and vesicular felsites similar to the rocks of the Coldbrook terrane in this part of the island. They also contain fragments of black flinty slate, like that of the pre-Cambrian terrane on the western side of the island.

On the opposite side of the Long island passage the Johannian division holds the shore from near Young point to the Long island ferry, with prevailing dips to the south-east. The beds stand mostly at high angles, and wave-marks and other indications show
sils. that some of them are overturned. They hold beds of small Lingulellas, and a Beyrichia also occurs. Some of the flags have wave-marks; others are fretted with ripple-marks and worm trails; others again have burrows of Arenicolites and Monocraterion, and a few have trails of Eoichnites.

Wave ridges on slabs near the north end of Long island passage are transverse to a wave impulse from the north, others at the opposite end of this passage on Barachois harbour are tranverse to a wave impulse from the west; further south-west, along the shore of this harbour, wave marks were observed transverse to an impulse from the north-west. These different courses might indicate that Long island was a barrier to the waves in Middle Cambrian time, but more observations are required to sustain such an hypothesis, for in the valley of Indian brook, fourteen miles to the south-west of Barachois harbour, wave-marks on the Johannian flags were found both parallel with and transverse to the course of the valley through which that brook runs.

Wave markings.

McMullin brook, one of the feeders of Indian brook, is about two and a quarter miles north-east of Dugald brook. It shows no section of the Etcheminian terrane, but for the St. John terrane it supplies the section which is wanting on the latter brook. It has a devious course, but shows numerous beds of this part of the Cambrian rocks. As in the case of Dugald and Gregwa brooks, there are falls where it descends from the Cambrian plateau to the level of Indian brook; but, while in the case of the two latter brooks the cascades are at the contact of the Coldbrook effusives with the Etcheminian, on McMullin brook it has not cut so far back, but is toward the base of the Johannian division of the St. John terrane.

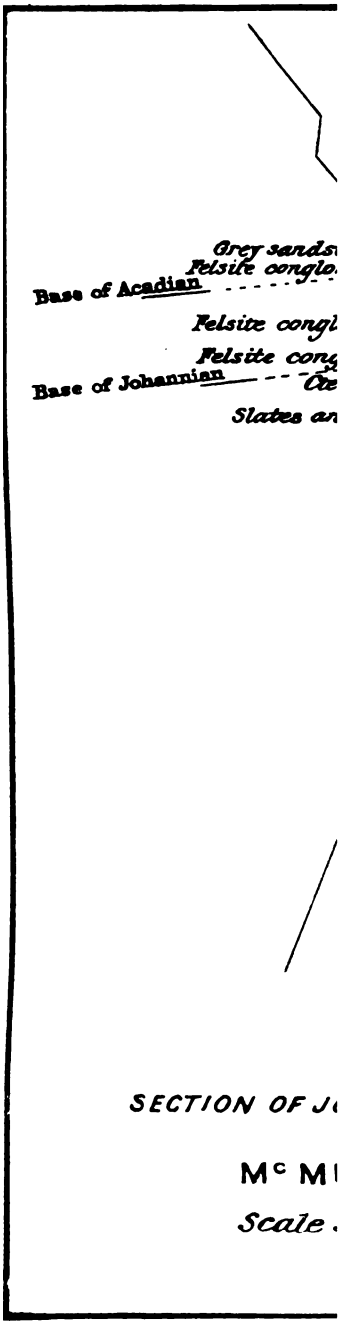
Johannian strata on McMullin brook, in Indian brook valley.

This stream is instructive in giving a section of the entire Johannian division which we did not meet with elsewhere in Indian brook valley. The Etcheminian terrane does not appear in this section, because the stream for a furlong above the lowest outcrop of the St. John terrane runs through an alluvial flat. The first beds seen, greenish-gray sandstones, with a thickness of 35 feet, are perhaps of the former terrane. *(See map on next page.)*

Following these are :—

Section on McMullin brook of Acadian and Johannian divisions of the St. John group.

| | | |
|---|---|---|
| 30 | feet | hard gray conglomerate full of felsite pebbles. |
| 50 | " | measures concealed. Here the road crosses. |
| 37 | " | purplish gray felsite conglomerate, with fragments of purple felsite, passing upward into purplish red sandstone. |
| 38 | " | hard gray felsite conglomerate. |
| 40 | " | compact gray sandstone. Dip S. 20° E. mag. < 65° |
| 195 | " | Measures of the Acadian Division. |


Grey sands
Felsite conglo
Base of Acadian
Felsite congl
Felsite cong
Base of Johannian
Ore
Slates an
SECTION OF J
Mc M
Scale .

| | | |
|---|---|---|
| 25 | feet | greenish gray conglomerate with felsite fragments and felsitic sand. |
| 45 | " | fine-grained gray shale and earthy sand-tone. Dip S. 40° E. mag < 65° ? At the top of this band is a bed of quartzite one foot thick, on the underside of which are moulds of the burrows of Arenicolites, tracks of worms, and trails of Ctenichnites (n. sp). |
| 65 | " | compact gray slate and some quartzite. Across two small falls to the main fall of this brook. |
| 80 | " | same rocks in gorge below the fall. Here the flags have wave marks 3 inches between crests. |
| 160 | " | similar rocks. Dip < 65°. |
| 165 | " | gray clay slate and flags. |
| 145 | " | same rocks, Claw marks of crustaceans. |
| 60 | " | same rocks, with wave-marked layers. Dip S. 25° E. mag. < 80°. |
| 60 | " | gray slates and quartzites. High cliff in the right bank. |
| 280 | " | same kind of rocks. Sides of the valley are lower. |
| 60 | " | measures concealed except some slates and flags in the left bank. |
| 75 | " | intervale flat of Indian brook. |
| 1220 | " | Measures of the Johannian Division. |

Compared with section at Boundary brook.

On comparing this section with that on Boundary brook three miles to the south-west given on a former page, there appears a similar series of felsite-conglomerates in the Acadian division of the St. John group, but as the intervening shales or slates and sandstones do not correspond in thickness in the two sections, satisfactory correlation of the conglomerates cannot be made; the conglomerates, however, are similar in kind and the difference in thickness is not very great. In the vicinity of the falls, both above and below them, the strata exposed are characteristically those of Division 2 Johannian, and contain trails of Ctenichnites, and trails and burrows of worms, such as are met with in the rocks of this division elsewhere. The group, however, shows a much greater width here than on Boundary brook, where a large part of its mass is cut out by the great fault running along the east side of Indian brook valley. At McMullin brook this division shows a full thousand feet in thickness of measures, and is thus as bulky as in typical sections in the city of St. John in New Brunswick.

umbaginous tes at the outh of igald brook.

At the mouth of Dugald brook, a little further down the valley, a narrow band of black plumbaginous slates shows itself next the granite. These would belong to the Bretonian division, so that there is reason to suppose that this twelve hundred feet of the section on McMullin brook represents the whole of the Johannian division as it is developed in the Indian brook valley. An examination of Indian brook from the mouth of Dugald brook downward shows little beside the Johannian division. For two miles, or as far as the highway bridge, the channel runs close to the foot of a high ridge of pre-Cambrian syenite, with exposures of flags, quartzites and arenaceous slates in the bottom of the valley. They vary somewhat in strike, but generally this is parallel to the course of the stream.

Indian ook there ripple arked flags.

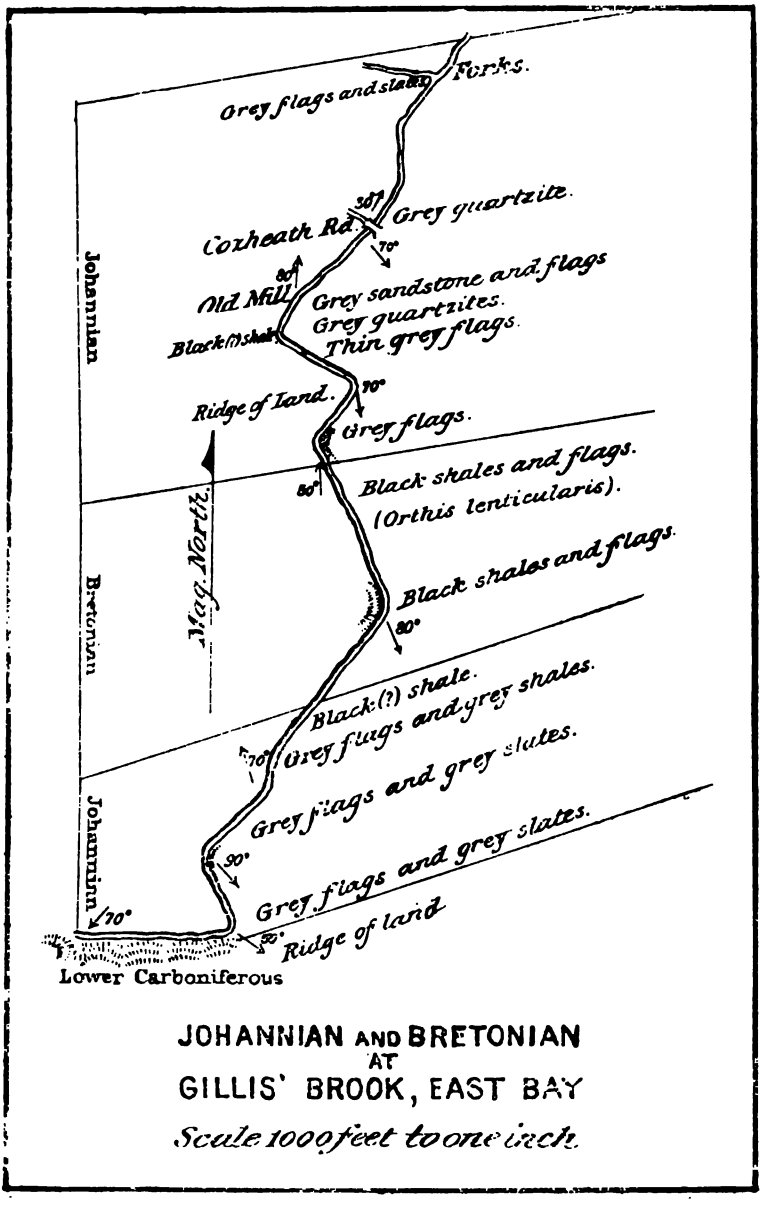
These beds are sometimes overturned, as is shown by the worm-burrows and wave marks on the flags. The ripples are occasionally parallel to the course of the stream (and valley) and at other times at right angles to it. No such wave-marks could have been produced by waves transverse to the course of this narrow valley, if the contour of the land had then been such as it is now. The hills which bounded the valley in Etcheminian time had at this epoch of the Cambrian passed below sea-level, and the Cambrian deposits made in it were subject to the mouldiag influence of the ocean waves.

mbrian pressed be- een syenite ges.

Below the highway bridge the Cambrian flags and quartzites form an anticlinal fold, of which the eastern slope is depressed toward the southern syenite ridge, and the western is cut off by an encroaching syenite ridge on the opposite side of the valley. These two ridges meet a mile above the mouth of the stream, so that the Cambrian basin terminates here abruptly. As neither the Coldbrook nor the Etcheminian terranes are seen at this end of the valley, and as the lower division of the St. John terrane is not in view, the whole Cambrian must here have sunk many hundred feet along fault lines into the pre-Cambrian complex.

hannian ision at Intosh ook.

A limited outcrop of the flags of the Johannian division is found at McIntosh brook on East bay, half a mile above its mouth. It consists of gray flags and shales in frequent alternations; dip S 10° E. mag. $< 70°$. Loose pieces of the flags contain Lingulella (sp.) and more rarely Acrothele (sp). Resting on these are gray rubbly shales, soft and micaceous, with Arenicolites and other worm burrows. They are cut off at the left bank by the crystalline volcanic rock mentioned by Mr. Fletcher. The Cambrian area is small and no other part of the Cambrian terranes were seen here, as overlying Lower Carboniferous limestones and shales conceal their extension.




JOHANNIAN AND BRETONIAN
AT
GILLIS' BROOK, EAST BAY

*Scale 1000 feet to one inch.*

ieminian pruce ɔk.

There is a considerable area of Cambrian rocks near the head of East bay, on its northern side, which was examined; it extends from Spruce brook to Gillis brook. At the first brook, exposures are limited in extent in the western tongue of a basin covered on the east and south by Lower Carboniferous deposits. On the west branch of Spruce brook at the foot of the granite hills are purplish gray sandstones containing valves of Lingulella and Acrotreta; these beds dip N. 10° E mag. < 50°; they may be assigned to the Lower Etcheminian. There are some beds of felsite and of felsite-grit intercalated with these sandstones.

ɪbrian ta on is' brook.

An examination of the Cambrian areas on Gillis brook was made above and below the point where the Coxheath road crosses it. *(See map on preceding page.)* At this point there is a width of 2,000 feet or more of the Johannian division, much folded and crumpled. Above the bridge at the Coxheath road there is a large quantity of gravel and boulders along the stream and the ledges are seen only at intervals. Below the bridge the stream has cleaned out its valley, and runs with a tortuous course through a ridge of quartzites and flags to a flatter tract where it has a more regular flow through rounded hills of black and dark-gray shale of the Bretonian division, whose measures have a width on the surface of 1,500 feet.

rm burs and ɪled flags.

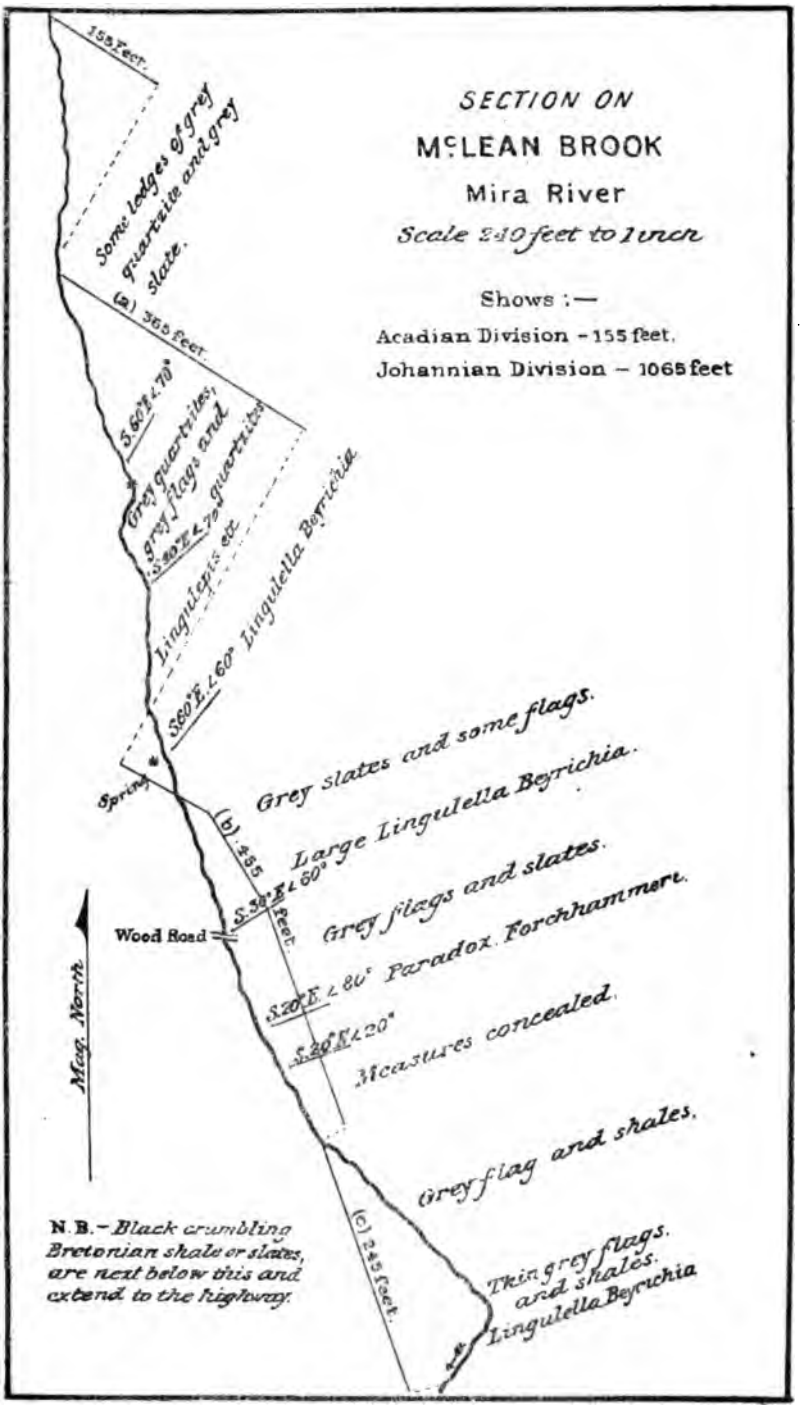
Below this the stream crosses another band of the gray flags of the Johannian division and again becomes more tortuous, with high banks until it meets Lower Carboniferous feldspathic conglomerates. The flags and slates have worm galleries of Arenicolites and pits marking the lairs of Monocraterion. Ripple-marked and wave-marked flags are present here, with spaces of three to five inches between the crest of the wave ridges. In the dark gray shales of the Bretonian division further up stream there are a few thin limestone beds and lentiles, in one of which valves of *Orthis lenticularis* are plentiful.

tonian sion.

The lower part of the St. John group was not seen, nor was any older Cambrian terrane observed, this Cambrian area being separated on both sides from the pre-Cambrian rocks by Lower Carboniferous deposits. The best section of the Johannian division of the St. John terrane in the Mira valley is that exposed on McLean brook, near Marion bridge. This section has been exploited by Mr. S. Ward Loper, who has collected there extensively for the United States Geological Survey. *(See map on opposite page.)*

ɪion of annian IcLean ɔk, Mira r.

Here the whole series of the flags and slates of this division are exposed in the valley of the brook, which cuts across them transversely. They dip down the stream at an angle of 70° to 50° and rest upon


SECTION ON
McLEAN BROOK
Mira River
Scale 240 feet to 1 inch
Shows :—
Acadian Division - 155 feet.
Johannian Division – 1065 feet
155 Feet.
Some ledges of grey quartzite and grey slate.
(a) 365 feet.
S.60°E. ∠70°
Grey quartzites, grey flags and quartzites
S.80°E. ∠75°
Linguicepis etc.
S60°E. ∠60° Lingulella Berrichia
Spring
Grey slates and some flags.
(b) 485 feet.
S.30°E. ∠60°
Large Lingulella Berrichia.
Grey flags and slates.
Wood Road
S.20°E. ∠80°
Paradox. Forchhammeri.
S.20°E. ∠20°
Measures concealed.
Grey flag and shales.
Mag. North
N.B.– Black crumbling Bretonian shale or slates, are next below this and extend to the highway.
(c) 245 feet.
Thin grey flags and shales.
Lingulella Berrichia

about 150 feet of dark gray slates of the Acadian division, of which the base is concealed by surface deposits and woodlands.

Of the Johannian there are about 1,060. Of this thickness 365 feet in the lower part may be assigned to the section *a;* in it there are some heavy quartzite beds which have given rise to a fall on the upper part of the stream; the lower half of this, above the falls, has much dark slate interstratified.

The middle section *b*, of about 455 feet, is mostly composed of flags and slates, and is more fossiliferous; a Lingulepis allied to *L. Starri* of the corresponding horizon in New Brunswick, is quite plentiful; and a Beyrichia, *Beyrichia triceps*, n.sp., with a high anterior ridge on the valve, occurs. In the upper part of this section Mr. Loper found a few examples of a variety of *Paradoxides Forchhammeri*. It differs from the typical form in being smooth on the glabella, but it is warty on the slope of the cheeks like that form.

Paradoxides in this division.

The upper section *(c)* of about 245 feet is composed of softer and more micaceous flags and slates, in which fossils were not found so abundantly; those that occur are of smaller size than the species of the middle band. Following these and resting upon them are black and dark-gray fine, soft, crumbling slates that have a considerable width, and are the last rocks exposed in going down the stream. These would belong to the Bretonian division.

Curving course of measure on McLean brook.

The section of this brook shows the same curving of the strata around the McCodrum ridge as Mr. Fletcher noticed in the Etcheminian terrane on McCodrum brook. In the lowest exposures of the dark gray Acadian slates on the upper part of McLean brook the dip is S. 40° E. mag.; at the falls in the quartzites, etc., of the lower section *(a)* it is S. 60° E. mag.; higher measures of the same section return to S. 40° E. mag.; in the middle section the dip varies from S. 50° E. mag. to 40° E. mag.; in the upper part of this section it changes to S. 20° E. mag., and so continues to the top of the Johannian division. The change of strike is about forty degrees, which agrees with the change observed by Mr. Fletcher on McCodrum brook.

Johannian division in Mira valley concealed by heavy covering of drift.

The sections of the beds of the Johannian division seen elsewhere in the Mira valley, are so partial, owing to the heavy drift covering in this valley, that no satisfactory proof of the thickness of this member was met with, other than in this section, but it will be noticed that this section agrees nearly in the thickness of the beds with those exposed on McMullen brook in the Indian Brook valley.

But though there are no clear sections of this division in the Mira valley that have come under our observation, except at McLean brook, there is ample evidence that it is well developed there. In the centre of the valley is an important settlement known as 'Big Ridge,' which is spread along the principal ridge of Johannian rocks in this valley. It lies between McNeil brook and Trout brook, and extends to the old French road. On each side of this main ridge are two other lower swells of the same rocks, one filling in the space between McNeil brook and the Mira river (except the narrow belt of Bretonian shales extending along the course of McNeil brook), the other lying in the valley of Trout brook. The rocks of these several ridges meet along the Mira river, which is bordered by Johannian flags and s'ates from Marion bridge well down toward Albert bridge.

Ridges at McNeil brook.

*The Bretonian Division.*

In the Barachois valley, at the railroad cutting on the east side of the Barachois pond, a considerable thickness of fine, dark, soft clay slates is exposed. These are the first measures going south and east of the Bras d'Or met with in Cape Breton, that can with certainty be assigned to the Bretonian division of the St. John group. At the east end of the cutting they dip S. 40° W. mag. < 5°; about the middle of the cutting their dip is S. 30° W. mag. < 10°. Here there is a small syncline, and at the further end of the cutting the dip is increased to S. 30° E. mag. < 50°. Although there are some rows of small calcareous lentiles in these beds, by which the dip was determined, no fossils were found in them.

Bretonian division at Barachois road.

McLeod brook enters the upper end of Barachois pond. Following up this brook, no other part of the St. John terrane is met with besides these soft dark slates. The valley along here is bordered by syenites on the south-east and by effusive rocks on the north-west. But near the head of the valley the Etcheminian sandstones previously referred to form a narrow border for a short distance on the north-west side. In ascending McLeod brook from the Barachois pond the dip of the Bretonian slates, where it has been observed, for a distance of two and a half miles up stream, is low—10 to 30 degrees; then the beds stand at higher angles and mostly dip toward the south-east side of the valley; but in other parts they also dip south-west and north-west. At Johnson's little brook, which comes down over a cliff of syenite, there is a thin bed of limestone containing shells of *Orthis lenticularis* and a Camarella (?); this limestone is contained in black carbonaceous shale. Mr. Fletcher found *Dictyonema flabelliformis* here.

Bretonian fossils on McLeod brook.

About half a mile below the Boisdale road bridge, McMullins little brook enters the main brook on the right. On this brook a short distance above its outlet are gray shales containing *Monobolina refulgens*, *Schizambon priscus* and parts of trilobites. At the bridge the same fossils and others occur in a shale bank on the right side. At McMullin's brook the dip is S. mag. and S. 40° E. mag. < 70° and 80°. About a quarter of a mile above the bridge is another shale bank on the right side having limestone lentiles with *Monobolina refulgens* and a Lingulella; here the dip is S. mag. < 60°. About a furlong below the bridge in the left bank a thin fossiliferous band crops out, dipping at a high angle, and carrying *Asaphellus* cf *Homfrayi*, a *Triarthrus*, a *Parabolinella* and other forms of the Tremadoc faunal Other exposures with fossils are found in this bank of the stream, further up.

Tremadoc fossils on McLeod brook.

It will be observed that the dip in this part of the valley is quite variable, but the rocks are not strongly cleaved, as they are at the Barachois. Notwithstanding the confusing dips and faults in some parts of the Cambrian terranes in the basin extending from George river station to the head of McLeod brook, one can note a general succession of the parts of the Cambrian system from the former to the latter place.

General upward succession from George river station to head of McLeod brook.

From the station named, where the oldest Cambrian sediments of this basin rest on the Coldbrook felsites and pre-Cambrian syenite, to Young point at the entrance of the Long Island passage, the rocks are Etcheminian. Behind this point the first division (Acadian) of the St. John group is cut out by a fault, but the middle division (Johannian) holds the shore of the eastern side of Long Island passage, to the head of Barachois harbour. Here it disappears beneath the upper, or Bretonian division, which extends thence to the narrow deep gorge at the French Vale road, near the source of McLeod brook. This arrangement would imply a differential uplift of the north-eastern end of the basin since Cambrian time, through which the whole of the terranes at this end of the basin have been eroded to the basal conglomerates. Complementary to this there has been a depression at the south-western end with the production of heavy faults on both sides of the Cambrian valley, by which the terranes have been let down between the bordering pre-Cambrian ranges for the whole thickness of the three terranes which constitute this system in Cape Breton.

Differential uplift of the north-eastern end of the Barachois basin.

Very different conditions and structure prevailed in Indian brook valley, which is a nearly direct continuation of the Barachois basin.

For the greater part of the length of this valley the measures are nearly or quite vertical and the succession of the Cambrian terranes is from side to side of the valley, *i.e.*, from the northwest to the south-east side, and the whole series may be crossed in the distance of three-quarters of a mile. But the series is not complete, as the Bretonian division is almost or quite removed by faulting and erosion from every section in this valley which it has been possible to examine, and the elisions on some sections cut out half the Johannian division as well. Cambrian beds vertical in Indian brook valley.

A few miles to the south-east of Indian brook basin, on the shore of East bay, there is a small outcrop of Bretonian shales and thin flags, (surrounded by Lower Carboniferous shales with gypsum) that carry a characteristic fauna. Here were found *Sphærophthalmus Fletcheri*, *Parabolina Dawsoni*, *Peltura scarabeoides*, *Agnostus trisectus*, and other forms of the Peltura fauna. Nearer the head of East bay, but inland from it on Gillis' brook, is the band of Bretonian shales already described, containing limestone layers with *Orthis lenticularis*, &c. Peltura fauna on East bay—fossils.

Two basins of Bretonian slates have been recognized in the valley of the Mira river. One lies in the depression above Marion bridge where the river widens out and takes on a lake-like appearance known as the 'Grand Mira.' This basin lies between Johannian sediments on McLean brook and a low broad ridge of rocks of the same age that extends from Marion bridge some distance up along the right bank of the 'Grand Mira'; the basin extends in a north-easterly direction where it passes beneath an area of Millstone grit of the Carboniferous system. The other basin is a narrow one on McNeil brook, a stream discharging into the Mira river on the eastern side below Marion bridge. This basin is pinched out on McNeil brook a little below where the bridge of the Trout brook road is placed. It forms a narrow trough extending along McNeil brook to and beyond the bridge where the 'Big Ridge' road (on the Geological map, the Caribou Marsh road), crosses. Beyond this point it has not been traced, but it may extend through a valley that runs along the north-western side of the Big Ridge and by McEchern's lake and brook connects with the 'Grand Mira.' It was from this basin on McNeil brook that the fossils were obtained which first showed the existence of Cambrian rocks in Cape Breton. The fossils from this basin, found on McNeil brook, are *Peltura scarabeoides*, *Spharophthalmus alatus* and several Agnosti and Lingulellæ. Two basins of Bretonian slates in valley of Mira river. Fossils of the Peltura fauna.

The area covered by Bretonian rocks in Cape Breton is insignificant compared with that occupied by Johannian or Etcheminian sedi-

ments. This is owing partly to their being of less volume originally, for they cannot be estimated at more than 500 to 700 feet in any of the three basins where they are so exposed that an approximate estimate can be made. But probably the chief reasons of the rarity of exposures of this part of the St. John terrane, are the softness of the slates or shales of which the division is composed, and to the fact that they form the uppermost division of the terrane, and therefore were the first to come under the destructive action of abrading agencies.

mate s of brian n eton.

A more careful examination of the field is necessary before a reliable estimate could be given of the thickness of the Cambrian rocks in Cape Breton, and the following are to be regarded as only an approximate estimate of their thickness.

| | East Bay | Mira Valley. |
|---|---|---|
| Coldbrook terrane ..... | 300 | Very thick. |
| Etcheminian terrane ..... | 500 | 3,000 ? |
| St. John terrane, viz :— | | |
| Acadian division ..... | 200 | 800 ? |
| Johannian division..... | 1,200 | 2,000 ? |
| Bretonian division ..... | 500 ? | 500 ? |
| | 2,700 ? | 6,300 ? |

## ORIENTATION.

Having observed a remarkable uniformity in the attitude of the valves of Brachiopods buried in the Etcheminian sediments of Indian Brook basin on the East Bay of the Bras d'Or, it occurred to the writer that an investigation of the causes that led to this would throw light on the physical history of the Cambrian deposit in relation to the life of that period.

of s of hio-

In the following remarks I shall use the term *orientation* to express the attitude in which the valves of the brachipods are found, wher opened up on the layers of the rock over which they are spread. Th beak of the ventral valves is found to point so uniformly in on direction that it can only be the result of some general cause whic has acted on these valves when living, or when about to be buried the mud on the sea-bottom.

These brachiopods when living would have been attached to t bottom by the pedicle or anchoring thread, as in the modern Lingu but were free thus to float in the sea water near the bottom. great majority of the shells buried in the Etcheminian sands

clays belong to the orders Atremata and Neotremata, both of which have representatives in the oldest Cambrian beds. In both, the pedicle must have had much durability, as it succeeded in holding the shell in position in a majority of cases until the latter was weighted down with the accumulating sediment falling from the turbid water.

Mostly of the orders Atremata and Neotremata.

The pedicle is an organic part of the animal and is composed of layers of chitinous and fleshy matter and is liable to decay on the death of the animal. Orientation presupposes that the pedicle lasted long enough to hold the shell in position until it was buried. The conditions in the Etcheminian beds show that the dorsal valve after the death of the animal and the decay of the muscles and ligaments might float off, and yet the ventral value would be held firmly in its place, presumably with the aid of the pedicle. All brachiopods do not have pedicles of equal strength and durability; this is clear as regards the Etcheminian forms, for some genera show greater susceptibility to orientation than others, and it may be noted that it is the larger species in which the orientation is more apt to be obscure. Outside of the influence of the pedicle, form seems to have a good deal to do with the attitude of the valves. This is manifest from the position assumed by shells of the genera Obolus* and Leptobolus† in certain layers of the Upper Etcheminian, for while only 33 p.c. of the valves of the former are oriented, 81 p.c. of the latter have yielded to the influences causing orientation. No genus shows more perfectly the influence of form on orientation than Acrothyra‡ entombed in the same beds with the above genera; in this genus 84 p.c. of the funnel-shaped ventral valves are affected by orientation, while this phenomenon can scarcely be traced in the attitude of the saucer shaped dorsal valves.

Importance of the pedicle in relation to orientation.

Acrothyra markedly oriented.

Leaving out of view the influence of the pedicle in holding the valves in a certain position while being entombed, it is easy to see that form has much to do with the phenomenon of orientation. We have seen how diverse in shape were the two valves of Acrothyra, and how differently the two valves acted in the process of burial, and that while the ventrals exhibit a high percentage of oriented valves, the dorsals show scarcely more than the natural quarter of their number so placed; we may on the contrary see how readily the valves of Leptobolus have responded to the causes producing orientation. In this genus both valves are oval and nearly alike, and this contour would favour the placing of the valves lengthwise in the line of the current of water in

* Obolus lens. † Leptobolus atavus. ‡ Acrothyra proavia.

which they lived, as being the position of least resistance. So it happens that both dorsal and ventral valves can be included in the record of orientation, without materially affecting the percentage; while to follow the same plan with Acrothyra would reduce the per-

tobolus idedly nted.

centage of oriented valves nearly one-half. Yet we notice that in Leptobolus there is a much larger proportion of *reversed* valves than in Acrothyra; that is of valves having the longer axis parallel to the direction of the flow of the orienting current, but with umbo, in place of the front of the valve, pointing in that direction. These *reversed* valves we regard as *affected* by orientation, but not oriented.

Their abundance in Leptobolus as compared with Acrothyra may be due to one of two causes. In Acrothyra the umbo was strong and heavy and in cases where the pedicle had perished, and the ventral valve sank to the bottom the point of the shell would touch first and the shell would swing on this as on a pivot, presenting its smallest and heaviest end to the force of the current. Another cause which might have helped to cause the diversity in the attitude of the valves of the two genera is that the umbonal region of the ventral valve in Leptobolus was thin and the pedicle correspondingly attenuated; if it perished readily the valve would be sooner at the mercy of the current, and so would orient with either end presented to the current, indifferently.

lus scarce- ffected by ntation.

In Obolus we note a genus which resembles Leptobolus in the inconspicuousness of the umbo of the ventral valves, but differs in having flatter valves which are circular; and although the valves are thicker and heavier, the weight is somewhat evenly distributed. These nearly round saucer-shaped valves have left but a very imperfect record of orientation, for in the lot examined one-third were oriented and 28 per cent reversed, thus 39 per cent show entire indifference to the course of the orienting current.

There are a few valves of Acrothele, but they are insufficient to be of value in this question of orientation. But, having in view the two genera first discussed, I think these clearly show a current passing in a north-east direction through Indian Brook valley when the Etcheminian terrane was being formed. At the same time there seems to be abundant proof of shore lines near at hand from which felsitic stones and sand were derived, and from which the felspathic sand and mud were swept that rapidly entombed these shells.

ORIENTATION of Brachiopods on 10 small slabs from the Assise E. 3 *e*. Oriented fossils in E.3 *e*.

| N.B.—Valves with umboes pointing S.W. are oriented; N.E., reversed. | Oriented. | Reversed. | Point S.E. | Point N.W. |
|---|---|---|---|---|
| *Obolus lens*—18 valves. | 1 | 2 | 1 | 2 |
| Oriented 33 % | 1 | 1 | 1 | — |
| Reversed 28 % | — | 2 | — | — |
| Pointing S.E. 17 % | 2 | — | — | 1 |
| " N.W. 22 % | 2 | — | 1 | 1 |
| | 6 | 5 | 3 | 4 |
| *Leptobolus*, chiefly *atavus*. | 22 | 7 | 4 | 6 |
| Both valves, 127 valves. | 9 | 3 | — | 2 |
| Oriented 53 % | 8 | 6 | 4 | — |
| Reversed 28 % | 9 | 5 | 1 | 1 |
| Pointing S.E. 11 % | 8 | 5 | 4 | 1 |
| Pointing N.W. 8 % | 7 | 4 | — | — |
| | 4 | 1 | 1 | — |
| | 1 | 4 | — | — |
| | 68 | 35 | 14 | 10 |
| *Acrothyra proxvia*. | 16 | 6 | 5 | 3 |
| Ventrals only, 158 valves. | 12 | 1 | 1 | — |
| Oriented 72 % | 7 | 6 | — | 1 |
| Reversed 12 % | 3 | — | 1 | — |
| Pointing S.E. 12 % | 13 | 3 | 8 | 1 |
| " N.W. 4 % | 18 | 2 | — | — |
| | 14 | 1 | — | — |
| | 6 | — | — | — |
| | 18 | — | 1 | 1 |
| | 7 | — | 3 | — |
| | 114 | 19 | 19 | 6 |
| *Acrothele avia*. | | | | |
| Both valves, 2 valves. | 1 | 1 | | |

The rock in which these fossils occur is gray and of fine texture and show a strong tendency to split along certain lines which are the layers where fossils are most abundant, and where the surfaces are lavishly strewn with little shells.

Finding such marked orientation in the valves of Assize E. 3 *e*, it was thought desirable to see if other horizons of the Etcheminian presented similar conditions and at another locality, so a test was made of some small slabs from the Assize E. 1 *d* on Boundary brook. The following table gives the result:—

ented
ngulepides
Assise E. 1
Boundary
ook.

ORIENTATION in eleven small slabs showing Brachiopods Assise E. 1 *d.* at Boundary brook.

| — | Oriented. | Reverted. | Point. S.E. |
|---|---|---|---|
| | 5 | 2 | 2 |
| | 8 | 4 | 1 |
| | 9 | 2 | — |
| Lingulepides, chiefly *L. Gregwa* from the | 7 | 4 | 2 |
| lowest Etcheminian fossiliferous hori- | 3 | — | — |
| zon on Boundary brook—100 valves. | 4 | — | 1 |
| Oriented 56%. | 4 | 2 | 2 |
| Reversed 16%. | 5 | 1 | — |
| Pointing S.E. 11%. | 4 | 1 | — |
| " N.W. 17%. | 4 | — | 1 |
| | 3 | — | 2 |
| | 56 | 16 | 11 |

Returning to Dugald brook I continued the examinat assises there. Four small slabs from the Assise E. 1 *c* did such satisfactory results. The species here are *Acrothyra si* a few examples of an Obolus. The Acrothyræ, unlike thos E. 3 *e*, do not lend themselves to orientation. Many are in or nearly vertical position (in relation to the layers of roc thrown on their sides like those of the horizon last named.

crothyra
ented in
ssize E. 1 *c*.

ORIENTATION in Assise E. 1 *c*. at Dugald brook.

| — | Oriented. | Reversed. | Point S.E. |
|---|---|---|---|
| *Acrothyra signata*, chiefly the mutation | | | |
| *sera*. | 3 | 4 | 1 |
| All ventral valves, 34 valves. | 7 | 3 | 1 |
| Oriented 41%. | 2 | 1 | 1 |
| Reversed 29%. | 2 | 2 | 2 |
| Pointing S.E. 15%. | | | |
| " N.W. 15%. | 11 | 10 | 5 |

These and the following table give the best examples of in the Lower Etcheminian, but in others of these lower ass not at all well marked. Taken collectively the assises of Etcheminian do not exhibit by any means so clear an exem of the phenomina of orientation as those of the Upper Etch

Some small slabs were tested from Dugald brook from the same assise as those above mentioned on Boundary brook. These show a more decided orientation than the preceding :—

ORIENTATION in four small slabs—Assise E. 1 *d*.

Lingulepides oriented in Assise E. 1 *d*, Dugald brook.

| —— | Oriented. | Reversed. | Point S.E. | Point N.W. |
|---|---|---|---|---|
| *Lingulepis Gregwa*. | 2 | 1 | 1 | 2 |
| Ventral valves, 18 valves. | 3 | 1 | 1 | — |
| Oriented 56%. | 3 | — | — | 1 |
| Reversed 11%. | 2 | — | — | 1 |
| Pointing S.E. 11%. | | | | |
| " N.W. 22%. | 10 | 2 | 2 | 4 |
| *Lingulepis Gregwa-robusta*— | 5 | 3 | 1 | 1 |
| Both valves, 39 valves. | 9 | 2 | 1 | — |
| Oriented 66%. | 5 | 2 | — | — |
| Reversed 21%. | 7 | 1 | 1 | 1 |
| Pointing S.E. 8%. | | | | |
| " N.W. 5%. | 26 | 8 | 3 | 2 |

The ventral valve is thicker and is more regularly conical in this variety than in *L. Gregwa ;* these differences may have helped to give this form a more pronounced orientation than the *L. Gregwa* type.

Between the Gregwa shale and the top of Division 2 of the Etcheminian, coarse sediments prevail; brachiopods are scarce and give no data bearing on the orientation of the valves. But in some of the lower seams of Division 3, fossils are again numerous, and again show the effect of the orienting current. Here a new fauna comes in, but at first sparingly.

Acrothyra oriented in Assise E. 3 *a*.

ORIENTATION of fossils on a small slab from Assise E. 3 *a*.

| —— | Oriented. | Reversed. | Point S.E. | Point N.W. |
|---|---|---|---|---|
| *Acrothyra proavia*, ventrals. | 4 | — | 3 | 1 |
| " " dorsals. | 1 | 3 | 3 | 1 |
| | 5 | 3 | 6 | 2 |

Here, as elsewhere, the dorsal valves of Acrothyra
tions of value as to orientation, but the high, prostra
do. A bed in this assise gave the following result:—

er fossils
nted in
ise E. 3 *a*.

ORIENTATION of valves on four slabs, layers from one inch apart, in the Assise E. 3 *a*.

| — | Layer. | Oriented. | Reverse |
|---|---|---|---|
| *Acrothyra proavia-prima*, ventral valves. | | | |
| Oriented 56% | 1 | 4 | 0 |
| Reversed 10% | 2 | 39 | 5 |
| Point S.E. 13% | 3 | 62 | 12 |
| Point N.W. 21% | 4 | 32 | 7 |
| | — | 137 | 24 |
| Dorsal valves. | 4 | 17 | 17 |
| *Obolus lens*, both valves. | | | |
| Oriented 60% | 1 | 2 | — |
| Reversed 13% | 2 | 1 | 1 |
| Point S.E. 20% | 3 | 1 | 1 |
| Point N.W. 7% | 4 | 5 | — |
| | — | 9 | 2 |

The dorsal valves, on one slab, of Acrothyra are r
how little they were affected by orientation. Thes
unusual number of oriented Obolus; many of these w
In the next assise above, orientation is well marked, as

ntation of
e genera
ssise E.

ORIENTATION in five small slabs from Assise

| — | Oriented. | Reversed. | Oriented. | Reverse |
|---|---|---|---|---|
| *Obolus lens*, both valves | 33% | — | 2 | |
| *Leptobolus atavus*, both valves. | 68% | 21% | 13 | 4 |
| *Lingulella.* | 66% | — | 2 | |
| *Acrothele abavia.* | 50% | 32% | 11 | 7 |
| | | | 28 | 11 |

Here Acrothele exhibits orientation to an unusu
other cases its round valves are found buried in th

tudes. Leptobolus shows the usual large percentage of oriented and reversed valves.

In the next assise are layers, over which are scattered the valves of Acrothele and an oval Leptobolus. The attitude of these valves is as follows :—

ORIENTATION of valves on three small slabs of Assise E. 3 *c*.

Fossils oriented in Assise E. 3 *c*.

| — | Oriented. | Reversed. | Oriented. | Reversed. | Point S.E. | Point N.W. |
|---|---|---|---|---|---|---|
| | % | % | | | | |
| *Acrothele abavia.* | 50 | 25 | 4 | 2 | 1 | 1 |
| *Leptobolus collicia.* | 78 | 13 | 35 | 6 | 2 | 2 |
| | | | 39 | 8 | 3 | 3 |

The second species here is more like a Lingulella in form than the Leptobolus in the assise below, and responded corre pondingly to the orienting force.

Orientation in the next assise shows similar conditions, but with other species.

ORIENTATION of valves on several small slabs from Assise E. 3 *d*.

Orientation of two genera in Assise E. 3 *d*.

| — | Oriented. | Reversed. | Point S.E. | Point N.W. |
|---|---|---|---|---|
| *Leptobolus atavus.* | 6 | 1 | .... .... | .. .. . .. |
| Both valves. | 3 | ..... . | ..... .... | 1 |
| Oriented 59% | 3 | 1 | ..... . | .... ..... |
| Reversed 21% | 4 | 1 | ..... ... | .. .. .... |
| Point S.E. 9% | 2 | 1 | 3 | ..... |
| Point N.W. 11% | 8 | 5 | 1 | 4 |
| | 26 | 9 | 4 | 5 |
| *Acrothyra proavia*, ventrals..... . ... | 5 | 2 | 2 | 1 |

Oriented 50%. Reversed 20%. Point S.E. 20%. Point N.W. 10%.

Here the proportion of oriented ventral valves in *Acrothyra proavia* is unusually low.

A description of the orientation features in the brachiopods of the next assise has been given on a previous page. There remains to record the result of observations on the fossils of the highest Etcheminian assise — E. 3 *f*.

ientation of sils in sise E. 3 *f*.

ORIENTATION in the valves of brachiopods in several small slabs from the Assise E. 3 *f* at Dugald brook and Indian brook. (Gillis' branch).

| — | Oriented. | Reversed. | Ori. ented. | Reversed. | Point S.E. | Point N.W. |
|---|---|---|---|---|---|---|
| | % | % | | | | |
| *Acrothele proles.* | 60 | 20 | 3 | 1 | 1 | ..... |
| *Leptobolus collicia-collis.* | 59 | 15 | 23 | 6 | 8 | 2 |
| | | | 26 | 7 | 9 | 2 |

marine rrent tra- rsed Indian ook valley Cambrian ne.

From the above observations and records it will be seen that there was quite a decided orientation of the valves of the brachiopods in a fixed direction in all the Etcheminian assises of Indian Brook valley, wherever these valves were in sufficient abundance to afford means of determining their attitude. Had the orienting current influenced the valves of only one or two horizons, or had these valves borne conflicting testimony at different levels, there might have been some question as to the cause of the phenomenon, but in view of the constant orientation here in a fixed direction thoughout Etcheminian time we can only conclude that this valley is of pre-Cambrian origin, and guided the course of a marine current that traversed it in a north-easterly direction.

It is a question for consideration whether this current was an ordinary shore current along the coast, or a tidal current. The following are some conditions which bear upon the latter hypothesis.

onditions of tombment fossils in a lal estuary.

It may be surmised that entombment in the mud of a tidal estuary would take place chiefly on the ebb-tide. On the flood-tide the waters coming from the open ocean would arrive free from sediment, but with the waves beating on the freshly submerged shore, and the possible contribution of river sediment coming into the head of the tidal estuary, the returning water, retiring with the ebb-tide, would carry a load of sediment to spread over the sea-bottom and bury such animals as had reached the limit of their vitality, or were unable to free them-

selves from the muddy deposit settling from the turbid water as its tidal flow abated.

Another reason why we might anticipate the burial of marine animals on the ebb tide, is that those which had nearly reached the limit of their life, would be revived when bathed in the fresh sea-current of the flood-tide, coming to them charged with an abundance of food; whereas they would be more likely to succumb in the turbid returning waters of the ebb-tide, which had been robbed of their nourishment by other animals of the Benthos. Hence from these two causes, it is probable the majority of the burials of marine animals in estuarine mud will occur on ebb-tide, and we may look for the orientation of the valves of animals that hung by a byssus or pedicle in the direction of the ebb-tide. In fact this may be seen on any sandy shore where a few stones serve to give a foothold for mussels. Another cause which would help to the same result would be the undertow resulting from the wave impulse from the ocean sweeping up into an open bay. The translation of water near the surface resulting from the impulse of these waves would have a complementary under-tow outward along the bottom of the bay.

Dying marine animals will be buried on the ebb-tide.

Supposing the burial of the Etcheminian organisms to have occurred at the time of ebb in a hypothetical estuary, occupying the Cambrian valley of Indian brook, the orientation of these organisms would imply that the estuary opened to the north-east and that its head was to the south-west, since the fossils are oriented to the north-east. But such a hypothesis is not supported by the actual condition of the Etcheminian sediment. For if the mouth of the estuary were to the north-east, it would be natural to look for a greater thickness of deposits in that direction, but the reverse is the case; for while on the Gillis branch of Indian brook the thickness of the Etcheminian terrane is considerably less than two hundred feet, on Dugald brook, two and a half miles to the south-west, it is five hundred feet, and at Boundary brook, two miles further south-west, it is five hundred and fifty feet.

These conditions imply that the mouth of an estuary in Indian Brook valley, if such existed in Cambrian times, was to the south-west and the orientation of the fossils should have been in that direction, and not to the north-east, the actual direction.

We therefore turn to the marine current theory as the more probable explanation of the orientation of the Etcheminian brachiopods of this valley. To give passage to such a current, we must suppose that the neck which now connects Indian brook valley with that of

A shore current the more probable cause of orientation.

McLeod brook was proportionally lower in Etcheminian times than now; otherwise there would not be a sufficiently open passage for the flow of the current from one basin to the other.

All along the Indian brook basin the Etcheminian sediments are replete with material derived from the rocks of the complex pre-Cambrian along the sides of that valley and the Coldbrook volcanics with which this was overlaid. The basin was bordered with a ridge of these rocks all along its north-western side; and from the exactness with which the marine current was directed along this basin it seems clear to me that there was a complementary pre-Cambrian ridge along the south-eastern side of the basin as there is now on that side of the valley. Both ridges were probably of greater elevation in Etcheminian times than now.

In the course of the writer's observations in Cape Breton. no other opportunity to test the orientation of the Cambrian brachiopod was met with, except at Young point at the north-east end of the Barachois basin, and the result here was surprisingly different from that obtained on Indian brook.

ientation of ıgulellas at ıung point ferent from ıt of Indian ıok.

The fossils at Young point are supposed to belong to the lower part of Division 2, a zone from which no orientation data were obtained on Indian brook. The fossils here are mostly Lingulellas of the species *L. Selwyni*, and the upper side of the layers (though the beds stand at a rather high angle) was satisfactorily determined by finding from eighty to ninety per cent of the shells with the hollow side up. This peculiarity in the attitude of shells buried in the mud of the Cambrian terranes is noticeable in many of the assises of the Cape Breton areas. Two causes may have helped to produce it. Gravitation causing the shell to sink to the bottom, would be best served by the shell presenting the side of least resistance, *i.e.*, the rounded side to the bottom. To this would be added the lifting power acting on the upper (inner) surface of the valves, of the decomposition of the organic matter in the fleshy parts of the body, producing a buoy, that would sustain the shell with the inner side uppermost while sinking to the bottom.

The fossils described in the following table were found in a number of seams of sandy shale in the lower part of the section and were in a thickness of about a foot of this shale. The record of orientation was made in reference to the cardinal points, and the shells of both the upper and the under side of each slab were noted.

ORIENTATION of Lingulellas in the sandy shale at Young point, Cape Breton, from middle division of the Etcheminian.

| | No. of Slab. | THE UMBO POINTS. | | | |
|---|---|---|---|---|---|
| | | N. | S. | E. | W. |
| In this table the upper row of figures for each slab denotes the number of valves on the upper surface of the slab, the lower row those on the lower surface. The prevalent current when these shells were buried ran to the S.E., as shown by the majority of the umbones pointed to the N. and W. | 1 | 7 | 3 | 3 | 2 |
| | | 28 | 12 | 8 | 26 |
| | 2 | 7 | 8 | 5 | 10 |
| | | 11 | 8 | 12 | 7 |
| | 3 | 24 | 21 | 14 | 35 |
| | | 12 | 12 | 15 | 17 |
| | 4 | 6 | 5 | 5 | 8 |
| | | 7 | 3 | 5 | 7 |
| | 5 | 10 | 2 | 13 | 12 |
| | | 17 | 6 | 5 | 17 |
| | 6 | 10 | 6 | 2 | 5 |
| | | 0 | 0 | 1 | 3 |
| | 7 | 15 | 8 | 5 | 21 |
| | | 10 | 11 | 5 | 1 |
| | | 164 | 105 | 98 | 171 |

Supposed to be due to meeting of two currents.

Young point is situated at the north-eastern end of the Barachois Cambrian valley and therefore midway between the northern extremities of the two pre-Cambrian ridges that bounded this basin; it might therefore be expected to give reliable indications of a current if any prevailed in this valley at the time these fossils were entombed, but the result was quite at variance with that obtained on Indian brook, as may be seen by studying the preceding table.

The observations of the orientation of these shells were referred to the cardinal point. If this be changed to correspond to the columns used to show the orientation in the Indian Brook basin, we find an average of valves pointing S.W. 138, N.E. 131, S.E. 102, N.W. 167. The orientation, therefore, was not to the north-east, as in Indian brook valley, but to the south-east, indicating that the current ran chiefly in this direction. But only 32 above normal are oriented in that direction, or only 77 per cent more than one quarter of the valves.

Orientation at Young point extremely variable.

A study of the table will show how exceedingly variable the courses are. This extreme variability would be explained by the existence here in Lower Etcheminian time of an eddy between two conflicting currents, one coming out of the Barachois basin, and another more powerful passing eastward across the end of the pre-Cambrian ridges that bounded that basin. Such a current may well have existed, for at present there are no pre-Cambrian rocks visible for a long way to the north of Barachois basin, the space in front being occupied by a wide extent of Lower Carboniferous and Carboniferous deposits.

imilarity Cambrian diments in ape Breton id other arts of Nova cotia.

In Cape Breton the Cambrian rocks have much the same lithological appearance as they have in southern New Brunswick, and they are hardened to about the same degree; and do not, any more than the latter, exhibit areas of metamorphic rocks, except the included islands and ridges of pre-Cambrian age. There are no intrusions of granite or other hypogene rocks, nor are there crystalline schists such as are met with in the areas referred to the Cambrian system in the mainland of Nova Scotia.

ime and iron well as lica common ments of the ambrian cks in Cape reton.

The process of hardening is most marked in the sandstones, which, when in heavy beds, are converted into pseudo-quartzites; yet we never meet with a true quartzite in which the grains or particles of sand are invisible from the filling of the interstices between the grains with silica. While the cement is to a great extent siliceous, showing that the sandstones have been steeped in heated waters, yet the strata often respond to the test for calcium-carbonate, an evidence that the cement is in part calcareous.

In the flags of the Johannian division of the St. John terrane, which split readily along mud-seams, or mica-besprinkled layers, there are often numerous cross-joints filled with calcium-carbonate. When weathered, these flags fall to pieces at the joints, and the surface of the soil where they prevail, abound with angular sandstone fragments. The corresponding middle portion of the Etcheminian terrane, which is also quite arenaceous, carries a cement largely composed of carbonate or peroxide of iron; the latter is often sufficiently abundant to give a strong colour to these sandstones, or even at times to concentrate to irregular thin beds of red hematite. The strength of the cement which holds together the particles of the rocks of the middle members of the Etcheminian and St. John terranes respectively cause these members to stand out prominently, and they are consequently visible in raised ridges when other parts of their respective terranes are concealed from view by deposits of drift. They are therefore useful in revealing the structure of the Cambrian terranes, which otherwise would be difficult to unravel.

auses of ominence.

The prominence of the middle member (Johannian) of the St. John group, is the more marked because it is bordered both above and below by soft rocks. These softer members, originally mud-beds, are usually in the condition of slates; often they are so cleft as to have no visible bedding planes. In all this region the cleavage planes have

a general course of S.W. to N.E. and a steep hade, and where the dip of the bed is at an angle with the course, or the beds are flat, the fossils they contain are more or less distorted and often are quite unrecognizable.

There are two areas, however, which have not been so much affected by this cause of effacement of fossils, namely the valleys of McLeod and Indian brooks. A third, the Mira valley, also has fossils in good condition, especially when preserved in limestone layers.

Although there is considerable lime diffused as a cement through the Cambrian terranes, heavy masses of limestone are unknown in them. But a few thin limestone beds are found in the upper division (Bretonian) of the St. John terrane. This is in contrast with the rocks of the pre-Cambrian complex, which possesses large bodies of gray limestone, and with the overlying Lower Carboniferous terrane, in which also considerable limestone masses and gypsum beds are found.

Slates of the Coldbrook terrane disturbed more than those of the Etcheminian.

Some difference in condition may be noted between the slates of the Etcheminian and those of the Coldbrook terrane. The latter have suffered more from sliding movements so that the fossils in these slates have been much obscured; it is only where they have been imbedded in phosphatic nodules that the form 5 of the fossils have been preserved. But this can hardly be regarded as a proof that the terrane in which they are badly preserved has been subjected to greater metamorphism than the one in which the fossils are in better condition, for in the Coldbrook terrane these fossils are contained in a bed of slates only thirty feet thick, while the rest of the terrane consists of conglomerates, agglomerates and other trap-rocks, which would have resisted dynamical movements more energetically, and the slates would have suffered proportionately the more.

Cambrian of Cape Breton deeply buried.

The small amount of alteration which has affected the Cambrian strata in Cape Breton, would indicate that they have never been very deeply buried. The whole thickness of the three terranes was not sufficient to bring the lower beds within the influence of the heat of the earth's interior; and they could not at any time since their formation have been deeply buried beneath more recent terranes. And even the Lower Carboniferous may not have covered them everywhere, for Mr. Fletcher in several places represents the Cambrian as covered directly by the millstone grit.

The action of pressure from the direction of the Atlantic ocean is everywhere traceable in the Cambrian terranes, and quite corresponds

to conditions observable in the Cambrian areas of southern New Brunswick. In the Barachois basin, though the succession of members of the terranes is in ascending order from the north-east to the south-west, the cleavage planes are at right angles to this and so parallel to the direction of the pressure referred to.

So also in Indian brook basin, for the greater part of its length the Cambrian terranes are arranged in a single succession transverse to the valley, having been folded parallel to the valley and tranverse to the crowding pressure from the south-east. The Cambrian rocks of this valley, for the greater part of its length, display simply the north-east slope of a synclinal fold, of which the opposite slope has been uplifted and entirely removed by erosion in the long ages that have passed since Cambrian time. The pre-Cambrian platform on which this part of the fold rested, now stands up as a high ridge on the south east side of the valley, cutting it off from connection with the Cambrian basins along the shore of East bay.

Again, in the valley of the Mira river, overturned dips are prevalent along its south-eastern side, especially in the Etcheminian terrane, as may be seen on examination of Mr. Fletcher's map of that district. The whole series of the older Palaeozoic terranes along the north west side of the Mira valley also, are seen to dip seaward without overturned dips, and in the middle of the valley the anticlinal and synclinal folds are in a general way parallel to the Cambrian basins further to the north-west, so that the parallelism of structure of the ridges and valleys existing in pre-Cambrian times, along this coast, continued to be emphasized by a continuance of the pressure in the post-Cambrian ages.

# PART II

# PALÆONTOLOGY.

In consequence of the finding of trilobites, Brachiopods, etc., and of Cambrian genera in the Etcheminian strata, and for reasons given below, the writer proposes to revert to the classification of 1889, wherein these deposits are called the Basal Series (of the Cambrian System).*

Volcanic rocks at the base of the Cambrian.

It has been found that slates with fossils of Cambrian genera are included in the important group of volcanic rocks which lie at the base of the Etcheminian, and that where the dip of the volcanics can be found, as is not infrequently the case, it agrees with that of the Etcheminian. It is thought therefore that those volcanics (the Coldbrook group) should be included in the Basal Cambrian.

Both in New Brunswick and in Cape Breton the Coldbrook group begins with lavas showing deposition free of pressure, as they are amygdaloidal; or with agglomerates devoid of evidence of marked aqueous wear. The deposition therefore did not begin in deep water, or on exposed sea coasts, or under heavy pressure. The foundation upon which the volcanics rest shows in several places marks of deep sub-aerial decay at the line of contact. Calcareous bands are dissolved, leaving the silicious portion of the strata. The feldspar of the granitic rocks is kaolinized, and the magnesian silicates are hydrated, impure graphite beds are changed to a black amorphous crumbling shale, and a depression or narrow valley is usually found at the contact of the two terranes. These conditions appear to indicate that the pre-Cambrian complex had long been above the sea-level in these districts when the first Cambrian effusives were thrown out upon it.

Worn condition of the pre-Cambrian sediments.

Another point worthy of note in this connection is the large amount of feldspathic material in the Etcheminian beds; the very sands are often composed of feldspathic grains, and these largely of non-kaolinized feldspar, as though they had not been exposed to sub-aerial decay. Feldspar in this condition is found in two kinds of deposits, those that are the result

* Trans. Roy. Soc. Can., vol, vii, Sec. iv. p. 135.

of glacial wear and those found around volcanic vents, where particles of rock have been torn from the walls and blown out upon the surface of the earth. These if dropped into the sea would soon be covered up by fine mud and preserved in their original crystalline condition. The Etcheminian appears to represent largely the submarine condition of such effusive rocks. On the other hand, the Coldbrook series, as has been intimated above, represents the preceding sub-aerial phase of the eruptives. It is true that we find in many places conglomerates at the contact of these two series of rocks, thus diverse in appearance; but elsewhere there are no beds of rolled fragments at the contact, and the passage is direct from ash-beds or diabases, to the slates and sandstones. In reports of the Canadian Geological Survey of 1870-71, pp. 57–59, etc., relating to the province of New Brunswick, both these groups of rocks have been included in the Huronian system. They may be equivalent in age to the upper part of that series, but unfortunately the absence of fossils in the original Huronian leaves this matter in doubt.

Pre-Cambrian land in the Maritime Provinces

As we contemplate the physical conditions of the initial epochs of Cambrian time in the Maritime Provinces, we seem to see a region long elevated above the sea, now subjected to depression nearly to the sea level, the depression being accompanied with extrusion of lavas and volcanic mud and the ejection of stones and ashes. These at first were cast upon a land surface, but, as the crust of the earth continued to sink, it was covered by the sounds and bays of a shallow sea, diversified with pre-Cambrian ridges and islands, of greater or less extent.

For the above reasons, as well as because the stratified rocks of the underlying complex are markedly unconformable to the Cambrian, the volcanics are thought to belong to the latter, and to give the natural base of this system.

The accompanying table will then show the classification of the Cambrian system, as seen in the Maritime Provinces of Canada.

*(See accompanying sheet.)*

**Base of the Palæozoic Rocks in the Maritime Provinces of Canada.**

| Groups, and kind of Rocks in Cape Breton. | Canadian Reports. | European Writers. | | Maritime Provinces. | Leading Genera of the Several Groups. | English Equivalent. | |
|---|---|---|---|---|---|---|---|
| 3. Dark gray, and black carbonaceous shales often changed to slates; a few thin seams and lentiles of dark limestone, and some thin flags. | St. John Group of Canadian Geological Reports. | Primordeal (Cambrian.) | Lower Silurian. | 3. Bretonian Division. | *e.* Harpes, *Trinucleus*, in N. W. New wick. | Llandeilo. | |
| | | | | | *d.* Cyclognathus, Parabolinella, *Tetragraptus*, Didymograptus, in S. New Brunswick. | Arenig. | |
| | | | Ordovician. | | $c^2$. *Asaphellus*, Parabolinella, Triarthrus, Bellerophon. | Tremadoc. | |
| | | | | | *c.* *Dictyonema*, Monobolina, Schizambon, Acrotreta. | Dolgelly. | |
| | | | | | *b.* *Peltura*, Sphærophthalmus, Leptoplastus, Ctenopyge. | | |
| | | | | | *a.* *Parabolina*, Agnostus, Anomocare, Orthis, in S. New Brunswick. | | |
| 2. Micaceous gray slates, flagstones and quartzites. Iron bearing in Mira Valley, Cape Breton. | | | Cambrian. | 2. Johannian. | *c.* Agnostus, Lingulella. (Place of Olenus). | Ffestiniog and Maenterog. | Succession of the cambrian faunas in the Maritime Provinces and the rocks that concern them. |
| | | | | | *b.* *Paradoxides*, Beyrichia, Lingulepis. | Menevian. | |
| 1. Dark gray slates or shales with calcareous lentiles. Gray sandstones. Interrained conglomerates at and near the base. | | | | 1. Acadian. | *a.* Obolus, Lingulella, Lingulepis. | | |
| | | | | | *d e.* *Paradoxides*, Solenopleura, Ptychoparia, Microdiscus. | Solva. | |
| | | | | | *c.* *Paradoxides*, Conocoryphe, Liostracus, Agnostus. | | |
| | | | | | *a-b.* *Protolenus*, Ellipsocephalus, Beyrichona, Trematobolus, in S. New Brunswick. | | |
| 3. Fine greenish-gray argillites, some reddish-gray. Horizon of roofing slates, in C. Breton and Newfoundland. | Huronian of New Brunswick, in part. | Sparagmite Formation, Norway. | Basal Cambrian. (mihi). | Etcheminian. | 3. Upper. Solenopleura ? Ostracoda, 4 genera. *Acrothele*, Lingulella, Obolus Acrothyra, Hyolithes. | Caerfai. | |
| 2. Red sandstone and red and gray argillite. Lower iron-bearing horizon of Cape Breton Cambrian. | | | | | 2 and 1, Lower. *Holasaphus*, Paradoxidoid trilobite, Ostracoda, Billingsella, Lingulella, Acrothyra, Obolus, Hyolithes. | | |
| 1. Gray shale or slate with some quartzite and conglomerate, the latter especially at the base. | | | | | Lingulepis, Leptobolus, Obolus, Lingulella, Acrothyra, Acrotreta, Hyolithes. | | |
| Co. Dolorites, breccias and amygdaloidal ash rocks. Some gray shales about the middle. | | | | Coldbrookian. | Obolus, Lingulella, Linguledsis. Acrothyra, Acrotreta, Leptobolus. 2 Ostracoda. | Pebidian. | |

In this table we have been able to present one of the faunas of the European Cambrian, heretofore unrecognized in Eastern Canada, *i. e.*, the Tremadoc fauna of English writers, the Ceratopyge fauna of the Swedes (the Euloma-Niobe fauna of Prof. W. C. Brögger), the Dicello-
emadoc cephalus fauna of the Mississipi valley. This is based on the discovery of
red. examples of Asaphellus, Parabolinella and Triarthrus in soft shale on the upper part of McLeod brook, in Boisdale district. It happens that at St. John, New Brunswick, the strata which would carry this fauna is in the channel of the river in the upper part of the harbor of St. John, with the Dictyonema fauna on one shore, and the Tetragraptus fauna on the other, hence it has not been recognized in the St. John Basin.

Also, the strata of Division 2 of the St. John group, the Johannian division, which we have all along spoken of as the probable place of the Olenus, it would seem will have to be assigned largely to the Paradoxides zone, since Mr. S. Ward Loper, who has been collecting in Cape Breton for the U. S. Geological Survey, has found a *Paradoxides*, which the writer would regard as a variety of *P. Forchhammeri*, in the middle of this
Jpper Division. From this it may be inferred that the two lower bands (*a* and
xides" *b*) of this division may be assigned to the upper part of the Paradoxides
of zone. I had found in the Mira river Cambrian a cheek of Paradoxides
red. type in this division, but this alone was not sufficient to determine the presence of this genus in the Johannian division.

Another important point made during the past season was, that the strata at Youngs point (or McFees point), from which the fossils came, collected by Messrs. Weston and Robert many years ago for the Canadian Geological Survey, and which the author had described, and referred (on account of their resemblance to European forms) to the Ordovician fauna, are in the Etcheminian or basal Cambrian. The more abundant material gathered since Messrs. Weston and Robert's visit, show that the species referred by me to Orthisina is a Billingsella. The Holasaphus does not
phus agree with any other basal Cambrian trilobite so far described; but the Hyolithes may be a form of *H. americanus* of Billings.

The exploration in Cape Breton has added greatly to our knowledge of the Etcheminian Faunas. In New Brunswick we had already recognized two lithological divisions in the Etcheminian rocks, of which the lower was bare of any but the lowest forms of life, and worm trails; but some forms of higher types were found at the base of the upper division—Obolus, Hyolithes, Orthotheca.

In Cape Breton fossils occur at numerous levels throughout the Etcheminian rocks, and even in the Coldbrook volcanics there is a fauna. And

it would appear that three important faunal changes can be traced in the fossils of this Basal part of the Cambrian system.

*A conspectus of the several fossiliferous zones of the Etcheminian and Coldbrook terranes of the Basal Cambrian in Cape Breton, with list of the species which occur.*

In making this tabulation of the species and varieties of fossils in these old Cambrian rocks it is necessary to use names in anticipation of the descriptions further on in this report. Many of the species have already been published in the Proceedings of the Royal Society of Canada, in the Bulletin of the Natural History Society of New Brunswick (St. John, N.B,), and in the Canadian Record of Science; but the descriptions are reproduced here as they have not appeared in any official report, and because there is additional information to present with a number of the species.

The assises or zones are taken in their order from the oldest upward.

## COLDBROOK TERRANE, ASSISE "CO."

This is the only assise in which fossils have been found, in this terrane. It consists of a body of gray shales about thirty feet thick, lying near the middle of the terrane. The layer in which the fossils were found in chief abundance was a bed of compacted, slicken-sided shale, from a pure gray to a lavender gray in colour, and having a few grains of feldspar sand, and scattered grains and pieces of calcium phosphate. The rock is harder than the shales resembling it in the Etchminian terrane above, though it is not any more silicious or sandy, and it lies between masses of volcanic rock, chiefly ash beds and feisites. The presence of these shales in the midst of the volcanics indicates a temporary cessation of volcanic activity; and that the deposition of the fossiliferous bed occurred in comparatively clear water is shown by the grains and lumps of calcium phosphate, with which it is charged.

Fossiliferous assise in the Coldbrook volcanic rocks.

Though thus peacefully interred, the valves of the Brachiopods were afterward subjected to disturbing agencies by which they were twisted and distorted, so that for many of the valves, the species, and even the genera are unrecognizable. Hence it comes that the numbers given in the list below do not by any means show the abundance of the fossils, as many were not worth preserving. When the fossils happened to be buried in calcium phosphate or filled with this mineral, the form was preserved and it is mostly these that are listed. The smallness and the

roundness of many of the grains of calcium phosphate would lead suspect the presence of Foramenifera, but I was unable to obse smooth pitted surface by which the Foramenifera of the Protolem may be recognized.

of
ise.

| | | | | |
|---|---|---|---|---|
| Hyolithes, small, tubes | | | | 3 |
| Acrothyra signata-prima | ventral | 18, | dorsal | 16 |
| Acrotreta papillata-prima | " | 1 | " | 0 |
| Leptobolus torrentis | " | 1 | " | 0 |
| Lingulepis pumila | " | 3 | " | 4 |
| Lingulella cf. longovalis | " | 1 | " | 1 |
| Obolus torrentis | " | 1 | " | 1 |
| Indiana ovalis-prima | carapace | 1 | right v. | 1 |
| Escasona?? ingens | | ? | left v. | 1 |

Notwithstanding that all these genera are Etcheminian, and t can no longer separate the Coldbrook volcanic rocks as pre-Cam there appears to have been an advance or growth in the species a pass upward to the next terrane. This will appear as regard size if they be compared with the most nearly related Etcheminian

ative
ness

| | mm. | | mm. |
|---|---|---|---|
| Acrothyra signata-prima | 2x2¼ | A. signata | 2x3 |
| Acrotreta papillata-prima | 2x2½ | A papillata | 2½x2½–3 |
| Leptobolus torrentis | 3x2 | L. atavus | 5x3½ |
| Lingulepis pumila | 6x4½ | L. longinervis | 11x8 |
| Lingulella cf. longovalis | 7½x5 | L. longovalis | 9x6 |
| Obolus torrentis | 6x6 | O. triparilis | 9x8 |
| Indiana ovalis-prima | 5½x3½ | I. ovalis | 4½x3¼ |
| Escasona?? ingens | 6x6½ | ? | |

The fossils of the first column are of the Coldbrook terrane, t the second, Etcheminian.

Throughout the inarticulate Brachiopoda represented here, appears to have been an average increase of nearly fifty per cent, the length and breadth of the valves in the resembling forms Etcheminian (Lower) fauna. There seems not to have been a div of the species of this assise from incongenial habitat, as its fac should rather have shown larger species. In the Etcheminian terra advent of shaly beds was accompanied by the appearance of larger s as for example the two typically largest species of the two Etchem faunas, *Lingulepis Gregwa* (Assise E. 1 d.) of the Lower terra *Obolus Bretonensis* (Assise E. 3 d.) of the Upper.

## DESCRIPTION OF THE FOSSILS OF THE COLDBROOK TERRANE.

ACROTHYRA SIGNATA-PRIMA. Plate I, figs. 1 *a–g*.

Test (calcareo-)corneous; valves tumid. *Ventral valve* variable in form, longer than broad, often quite tumid, with the posterior half straighter than the anterior, which in some examples is strongly arched down toward the margin. Hinge area variable in height, beak sometimes overhanging the hinge, sometimes withdrawn from the perpendicular. *Interior*—There is a visceral callus from one-quarter to one-third of the length of the valve, wider in front than behind, bordered by vascular grooves; the central depression is greater toward the apex than toward the front. Outside of the aforesaid grooves is another and a shorter pair, more widely diverging; traces of the lateral muscle scars are seen outside of this latter pair of grooves. Acrothyra signata-prima.

The *dorsal valve* is more regular in form than the ventral, but also often quite tumid. The umbo is low and close to the margin. *Interior*—This possesses a shallow median septum extending to the middle of the valve; on each side of the septum, at the hinge line, are pits for the cardinal muscle. A pair of diverging grooves in the posterior half of the valve mark the position of the lateral muscles. Both valves have thickened borders and are flattened inside along the lateral margins. Considering the variableness of this form, one might be disposed to think it a mutation of *A. signata*, and it is so classed here; but the following differences are apparent: The visceral callus of the ventral valve is broader and not so distinctly impressed, and the grooves at the posterior end project farther backward. In *A. signata* the callus does not have the strong bounding ridges that this frequently is seen to have. The cardinal area in this form never has the extreme over-hang that marks *A. signata*, and the back part of the ventral valve is not produced.

*Sculpture.*—The surface is smooth, but a strong lens reveals fine concentric ridges at intervals on the surface of the shell.

*Size.*—Ventral, length, 2⅓ mm.; width, 2¼ mm.; depth, 1¼ mm. Dorsal, length and width, 2¼ mm.; depth, ¾ mm.

*Horizon and locality,*—Fine gray shales in the volcanic beds of the Coldbrook Group at Dugald Brook, Escasonie (C.B.), N. S.

ACROTRETA PAPILLATA-PRIMA, n. mut. Pl. III, figs. 1 *a–c*.

Only the *ventral valve* of this form is known. This is wider than long, tumid, with the cardinal area vertical. *Interior.*—In this the visceral Acrothyra papillata-prima.

callus is of a circular form, and only one-quarter of the length of the valves. Its ridge closely encircles a deep pit, which lies just in front of the foraminal opening, in the direction of which it becomes narrower and shallower. The traces of a pair of straight diverging grooves are discernable at the sides of the callus.

*Sculpture.*—This consists of minute concentric ridges, visible only with a strong lens.

*Size.*—Length, 2 mm.; breadth, 2½ mm.; depth, 1 mm.

*Horizon and locality.*—Fine gray shales in the volcanic beds at Dugald Brook, Escasonie (C.B.), N. S. Scarce.

The short callus distinguishes this species from *Acrothyra signata-prima* with which it occurs. The pit in this callus, though so short, is analogous to that of *A. signata*, so that in this earliest fauna these two types of umbonal muscle scar and groove of the Acrotretinæ were already differentiated.

### LEPTOBOLUS TORRENTIS, N. SP. PL. VI, FIG. 1.

lus
s.

Shell thin, surface shining. Form elongate-oval.

Ventral valve, obtusely pointed at the back somewhat acutely rounded in front; elevated along the middle; somewhat flattened along the sides within the margin.

*Interior.*—By decortication a low boss and a transverse furrow behind it are exposed on the mould, about three quarters of the length of the valve from the hinge; if this boss marks the front of the callus, the central muscles are unusually far forward, more advanced even than in *L. atavus* of the Etcheminian terrane. There are faint impressions of the lateral septa on the sides of the valve.

*Dorsal valve unknown.*

*Sculpture.*—The surface of the shell is covered with minute, low tubercles, cancellate in arrangement; through these can be traced faint parallel lines, concentric to the umbo. Along the median third in places can be seen about six broad flat ridges, radiating from the direction of the umbo; these break the continuity of the concentric ridges.

*Size.*—Length, 3mm; width, 2 mm; depth, ½mm.

*Horizon and locality.*—Gray shales in the volcanic rocks of the Coldbrook terrane. Scarce.

This little species is only known from a ventral valve. It is even smaller than *L. atavus* of the Etcheminian terrane and is flatter along the sides.

LINGULEPIS PUMILA, N. SP. PL. VII, FIGS. 5*a* AND *b*.

Lingulepis pumila.

Shell thick and long-ovate.

Ventral valve somewhat ridged toward the beak, which is much prolonged.

*Interior.*—The imprint of the foraminal groove on a mould of the valve extends one third of the length of the valve, and a faint imprint of the callus one-half the length or more. The dorsal is ovate with an obtuse back and straightened sides. At the front half of the valve are several strong concentric ridges, about seven in the space of a millimetre; behind these are others, more faintly marked. *Interior.*—A small exfoliated valve shows a median sulcus and faint print of muscle scars about the middle of the valve.

*Sculpture.*—This consist of irregular concentric ridges, about six in the space of a millimetre, near the back the concentric ridges are much more minute.

*Size.*—Length of the ventral valve 6 mm.; width, 4½ mm.; depth, 1 mm.

The dorsal is about 1½ mm., shorter than the ventral.

*Horizon and locality.*—Gray shales of the Coldbrook terrane at Dugald Brook, Escasonie.

LINGULELLA cf. LONGOVALIS. Plate VII, fig. 2.

Lingulella cf. longovalis.

A single example of a thin shelled Lingulella of the form and size of the above named species of the Lower Etcheminian Fauna was found. The outline has been preserved by a filling of calcium phosphate. The margin is somewhat acutely rounded in front, and the sides, somewhat flattened, are evenly curved from near the hinge. The valve has two or three strong growth grooves.

*Sculpture.*—This consists of fine irregular wavy ridges, made visible by the lens; there are about 6 ridges in the space of a millimetre. The ridges are irregularly granulated along the crest, the granulations being obscurely arranged in rows diverging from the apex; on the lateral slopes for a short distance, these low tubercles form more distinct curved ridges radiating from the direction of the umbo.

*Size.*—Length 7½ (?) mm.; width 5 mm.

*Horizon and locality.*—Same as the preceeding.

This species has a smoother surface than *L. longovalis* of the Etcheminian (Lower) Fauna, but otherwise much resembles it.

OBOLUS TORRENTIS, n. sp. Pl. VIII, fig. 1.

A few examples of shells were found which from their form should apparently be referred to the above genus.

The valves are broadly orbicular and moderately arched.

Ventral. Only an interior of a broken valve could be identified. It shows a thickening of the margin toward the hinges. *Interior.*—The cardinal area is laterally extended and is striated; the pedicle furrow is distinct and depressed.

Dorsal. An undersized exfoliated example was found, which is distorted by compression longitudinally, and shows traces of concentric ridges. There is a well-defined median sulcus on the mould extending forward from near the hinge.

*Sculpture.*—Unknown, except as above noted.

*Size.*—Length of dorsal 5½ mm. (probably shortened by pressure); width 6 mm. A rim of an Obolus from the same terrane is 8 mm. across.

This species is near the size of *O. triparilis* of the Etcheminian Lower Fauna, but is thinner, has a more obtuse beak to the ventral valve, and a weaker hinge area to the dorsal valve.

## OSTRACODA.

We have as yet only two forms that can be referred to this group of crustaceans, one a very peculiar one, the other similar to oval carapaces that are found in the beds of the overlying terrane. These will be found described in connection with other ostracoda of the Etcheminian terrane.

## ETCHEMINIAN TERRANE.

### ASSISE E. 1*a*.

This assise rests upon the effusive rocks of that last described. The lower part is a red amygdaloid that graduates upward into a red clay-slate, which in its turn is covered by a bed of trap. The fossils are scarce and are found in the slate. A large Hyolithes occurs here, an Orthotheca and worm burrows, also a large Brachiopod. The fossils are badly preserved.

## Assise E 1*b*.

The rock in which the fossils are contained is a greenish-gray sandy layer in lavender gray, rusty weathering, fine shale. The grains of the sandy layers are mostly of pellucid quartz and green quartz (some of a bright copper green). There are numerous minute fragments of red feldspar not kaolinized, (and some of red felsite). There is a pale green (magnesian) deposit in places among the sand grains. The sand is mixed with numerous fragments of the shells of Brachiopods and a few of Ostracods. The fossils found here were :—

*Fossils*—

Fossils of assise E 1*b*.

| | | | | |
|---|---|---|---|---|
| Acrothyra signata ..... | ventrals | 7, | dorsals | 4 |
| Leptobolus ?..... | " | 1 | " | 1 |
| Lingulepis Gregwa ? (mould)... | " | 1 | " | 0 |
| Lingulella longovalis ..... | " | 2 | " | 1 |
| Obolus triparilis..... | " | 3 | " | 4 |
| Bradorona spectator-acuta .... | right v. | 2 | left v. | 0 |
| B ———— observator-lævis. | " | 2 | " | 2 |
| Bradoria vigilans-obesa..... | " | 1 | " | 1 |

## Assise E 1*c*.

The rock here is also a fine gray to lavender gray shale, weathering pale brown in the cracks. The following species occur :—

Fossils of assise E 1*c*.

| | | | | |
|---|---|---|---|---|
| Acrothyra signata-sera..... | ventrals | 59, | dorsals | 53 |
| A ———— tarda ..... | " | 6 | " | 4 |
| Lingulella longovalis..... | " | 1 | " | 0 |
| Lingulepis Gregwa ..... | " | 0 | " | 5 |
| Eoobolus triparilis..... | " | 0 | " | 7 |
| Hyolithes sp. (wide apertural angle).. ..... ..... | tubes | | " | 2 |
| Orthotheca sp ..... | " | | " | 2 |
| Bradorona perspicator-maxima.. | right v. | 1 | left v. | 0 |
| B ——— spectator ..... | " | 1 | " | 0 |
| Bradoria ornata..... | " | 1 | " | 0 |
| B ——— vigilans, mut..... | " | 1 | " | 1 |
| Crustacean, part of a carapace with strongly pitted surface (part of cheek of trilobite ?) | " | | | 1 |

## Assise E. 1*d*.

The fossiliferous layers in this assise consist of gray and brownish gray shale, somewhat charged with fine sand, the sand grains being largely feldspathic particles. The rock was open in grain, and there are grains of a soft, grass green mineral, and of kaolinized feldspar (Gregwa shale). The species are as follows :—

| E 1*d* | | | | | |
|---|---|---|---|---|---|
| Acrothyra signata-tarda | ventrals | 24, | dorsals | 27 |
| Acrotreta papillata | " | 2 | " | 1 |
| Lingulepis Gregwa | " | 42 | " | 38 |
| ——————— var. robusta. | " | 5 | " | 1 |
| Orthotheca | tube | | " | 2 |
| Bradorona spectator | right v. | 0 | left v. | 2 |
| B ——————— acuta | " | 2 | " | 0 |

At Boundary brook in the Indian brook valley, some miles S.W. of Dugald brook there is some variation in the strata of this assise and a fuller fauna. The rock is a dark brownish gray feldspathic sandstone, full of small gray or pink grains of feldspar, and of darker feldspathic and quartzose grains ; fragments of dark gray felsite occur half an inch in diameter and less. The rock is not strongly cemented and is traversed by calcareous veins. The surfaces of the fossils are much corroded, and frequently only a thin film represents the fossil. The following occur here.

| E 1*d* ry | | | | | |
|---|---|---|---|---|---|
| Acrotreta papillata | ventrals | 25, | dorsals | 24 |
| A ——————— lata | " | 2 | " | 0 |
| Leptobolus atavus, mut. tritavus. | " | 5 | " | 3 |
| L——————— cf collicia | " | 3 | " | 1 |
| Lingulepis Gregwa | " | 40 | " | 44 |
| L——————— sp | " | 5 | " | 3 |
| Obolus sp. | " | 2 | " | 0 |
| Orthotheca sp. (broken) tube | " | | " | 2 |
| Bradorona perspicator | right v. | 2 | left v. | 2 |
| B——————— spectator | " | 5 | " | 9 |
| B——————— observator | " | 4 | " | 8 |
| B——————— ——————— benepuncta. | " | 3 | " | 2 |
| Bradoria vigilans, mut. | " | 1 | " | 0 |
| Escasona rutellum-prima | " | 0 | " | 1 |
| Schmidtella (?) pervetus-concinna. | " | 0 | " | 1 |

### Assise E. 1*e*.

The fossiliferous seams here consist of greenish gray sand, alternating with others that are lavender gray. The sand consists largely of grains of pellucid quartz; there are pale green particles and films which may be glauconite or some magnesian silicate. There are also black grains and a few lumps of calcium phosphate. Some of the fossils are fragmentary.

Fossils of assise E 1*e*.

| | | | | |
|---|---|---|---|---|
| Leptobolus sp ..... | ventrals | 1, | dorsals | 2 |
| Lingulepis Gregwa-robusta young 6..... ..... | " | 2 | " | 1 |
| Lingulella longovalis..... | " | 14 | " | 8 |
| Obolus discus ..... | " | 1 | " | 4 |
| O—— sp..... | " | 1 | " | 0 |
| Orthotheca, part of tube..... | " | 0 | " | 1 |
| Hyolithes..... | " | 0 | " | 1 |
| Bradorona spectator-spinosa.... | right v. | 1 | left v. | 1 |
| Indiana ovalis..... | " | 1 | " | 1 |

The above assises belong to the lower division of the Etcheminian, and although the matrix imbedding the fossils is fine it alternates with grit sandstones and quartzite in different parts of the division, so there was considerable diversity of conditions when this division was laid down. In the next division, the rocks are coarser and of a more uniform character.

### Assise E. 2 *a*

On Dugald brook there are in this assise two species of Lingulella but they are not in such a condition as to be worth study, as the shells have been subjected to much corrosion.

We have referred here provisionally the fossils of Young point near George river station, as they are in red sandy members of the Etcheminian and some distance above the base of the terrane. The species are:

Fossils of Young point assise E 2*a* 3.

Hyolithes cf. tenuistriatus, Lnrs., or princeps, Bill.
Leptobolus atavus, mut. insulæ.
Lingulella Selwyni.
Lingulepis Roberti.
Obolus discus.
Billingsella retroflexa.
Holasaphus centropyge.
A Paradoxidoid trilobite.
A Eurypterid (?) crustacean.

### Assise E. 2*b*.

The rock is a dark purplish gray sandstone, with abundant non-kaolinized red feldspar. The sandstone is strongly cemente some small calcite veins; from this and from other conditions i it would appear that the cement is in part calcareous. There iron in the sandstone to give it a rusty brown color when The rock contains pieces of black slate and small pebbles of qu

| | | |
|---|---|---|
| Acrothyra signata-tarda..... | ventrals 1, | dorsals |
| Lingulepis longinervis..... | " 9 | " |
| Orthotheca, tube ..... | | |
| Bradorona perspicator-magna, right | " 2, | left v. |

### Assise E. 2*c*.

of the E 2*b* The rock containing the fossils is a fine grained greenish gra with purplish clouding, but the main body of the assise is a pu feldspathic sandstone. The fossils found in this assise were :-

| | |
|---|---|
| Acrothyra signata-orta..... | ventrals 3, dorsals 2 |
| Bradorona observator-lævis, right | valve 2, left v. |

This is the highest assise in which the Lower Etcheminian found; above this, in the next division new species come in, a genus appears. Between the two fossiliferous zones is a th about 50 feet, in which only broken and imperfect Lingu collected. In this thickness of barren measures though the remains coarse and sandy, the purplish red color has disappear gray color prevalent in the upper division, is found.

### Assise E. 3*a*.

The fossiliferous layers are of lavender gray or pure g weathering yellowish in the cracks, so probably containing iron There is some felsite debris or feldspar grains, and minute s white mica. The species present are :—

| | | |
|---|---|---|
| Acrothyra proavia-prima..... | ventrals 7, | dorsals 1 |
| Acrothele abavia. ..... | " 1 | " |
| Leptobolus sp..... | " 0 | " |
| Lingulella sp..... | " 1 | " |
| Obolus lens..... | " 1 | " |

### Assise E. 3 *b*.

A bed of purplish gray shale with diffused hematite (giving the rock a purplish gray streak) contains the fossils. There are quite minute spangles of white mica. The fossils of this layer are much corroded and do not show good surfaces.

Fossils of the lower assises of E 3, viz. *a b* and *d*.

*Fossils*—

| | | | | |
|---|---|---|---|---|
| Acrothele abavia | ventrals | 12, | dorsals | 21 |
| A——— avia (?) | " | 1 | " | 1 |
| Leptobolus atavus | " | 5 | " | 7 |
| Obolus lens, young vtl. 2. | " | 4 | " | 3 |
| Trilobite, a pleura with a deep furrow | | | | 1 |

### Assise E. 3*d*.

A considerable body of gray and purplish gray shale, with very minute spangles of gray mica, " Bretonensis Shale."

*Fossils*—

| | | | | |
|---|---|---|---|---|
| Acrothele avia | ventrals | 5, | dorsals | 7 |
| A——— —— puteis | " | 14 | " | 10 |
| Leptobolus atavus | " | 32 | " | 33 |
| Obolus Bretonensis, young vnt. 1 | " | 6 | " | 4 |
| Bradorona spectator-æquata | right v. | 1 | left v. | 2 |

Of the Acrotheles above named, the first was found on Dugald brook, and the second on Gregwa brook.

### Assise E. 3*e*.

In this assise the gray shales become flaggy, and split into layers ½ to 3 inches thick; the fissile condition appears to be due to layers covered with fossils alternating with thin beds in which the shells are less abundant. The rock has fine spangles of silvery gray mica.

*Fossils*—

| | | | | |
|---|---|---|---|---|
| Acrothyra proavia | ventrals | 160, | dorsals | 160 |
| A——— crassa | " | 1 | " | 0 |
| Acrothele avia | " | 9 | " | 1 |
| A——— abavia | " | 5 | " | 0 |
| Leptobolus atavus | " | 69 | " | 63 |
| L——— collicia | " | 18 | " | 26 |

Fossils of the assise E 3*e*.

| | | | | |
|---|---|---|---|---|
| Lingulella, sp..... | ventrals | 0 | dorsals | 1 |
| Obolus lens..... | " | 17 | " | 16 |
| O—— —— longus..... | " | 3 | " | 1 |
| Bradorona observator-ligata. | right v. | 2 | left v. | 2 |
| Bradoria scrutator..... | " | 3 | " | 1 |
| B——— vigilans..... | " | 6 | " | 2 |
| B——— rugulosa..... | " | 5 | " | 3 |
| Indiana ovalis..... | " | 1 | " | 1 |
| Schmidtella (?) pervetus.... | " | 2 | " | 1 |
| S———— (?) acuta..... | " | 3 | " | 3 |

## Assise E. 3*f*.

Gray shale more sandy than the assise below ; some beds havs lish tint ; the spangles of a silvery mica, are larger than those ( Some of the highest beds are flaggy and more silicious.

of the
3*f*.

| | | | | |
|---|---|---|---|---|
| Acrothyra proavia-prima ?..... | ventral | 1, | dorsal | 0 |
| *A———— ——— crassa ?.... | " | 1 | " | 0 |
| *Acrothele proles..... | " | 23 | " | 12 |
| Leptobolus atavus..... | " | 0 | " | 1 |
| *L——— collicia..... | " | 6 | " | 2 |
| *L——— ——— var. collis.... | " | 21 | " | 16 |
| Hyolithes, part of tube..... | | | | 1 |
| Leperditia (?) rugosa..... | ventral | 1, | dorsal | 0 |
| Bradorona perspicator-major... | right v. | 1 | left v. | 0 |
| *Bradoria scrutator..... | " | 0 | " | 1 |
| Escasona rutellum..... | " | 0 | " | 2 |
| Indiana lippa..... | " | 2 | " | 2 |
| *Solenopleura Bretonensis, heads 2, cheek. 1, pleura 3 | | | | |
| *Eurypteroid Crustacean ? | | | head 1. | |

Though we have associated this assise with the Upper Etch Fauna, there are some changes in its species from the typical s of that fauna. *Acrothele avia* is replaced by *A. proles*, to which tl resembling species in the Paradoxides lamellatus Subzone in Nev wick ; also the large Leptobolus is chiefly a variety of *L. collici* presence of a Solenopleura might also be thought to indicate co with a higher fauna, but it has not the short eye-lobes of the s the Paradoxides Zone, and so may be considered more primitiv have therefore thought it advisable to follow the lithologica ind and include this assise in the Etcheminian.

*The species marked with an asterisk were found at Gilb[illegible]

## Fossils of the Etcheminian terrane.

Though remains both of Hyolithes and Orthotheca have been found at several horizons in the Etcheminian terrane, only at one locality are they in such a condition of preservation as to render it possible to make any attempt at designating the species.

### ORTHOTHECA, Novak.

This genus is represented at no less than five horizons of the Lower Etcheminian, but in all cases the material representing the tubes of these worms is so imperfectly preserved that no specific reference can be made.

Hyolithes cf. tenuistriatus.

### HYOLITHES, Eichwald.

Hyolithes *cf.* tenuistriatus, Linrs., Pl. IX, figs. 4*a* and *b*.

A large species of this genus occurs in company with *Lingulella Selwyni* in the gray sandstones of Young point, which is nearly related to the above Swedish species. It also resembles the Bohemian *H. maximus*, Barr., and the American *H. princeps*, Bill.

Apical angle about 12°. No grooves were observed within the margins on the dorsal side and no furrow at the median line on the ventral side. This valve is somewhat flattened on the sides but much more convex than the dorsal; on the average it is three times more convex, but the relative convexity is variable. The edge of the orifice of the shell on the ventral side is slightly bowed upward in the middle, and near each end is a sinus where the growth line curves downward and then upward before crossing over to the dorsal side, hence the rising arch of the edge on the dorsal side belongs partly to the ventral side.

The angles between the dorsal and ventral sides are sharp, especially in the apical half of the shell. The lip on the dorsal side is strongly arched upward, and the surface striæ correspondingly curved.

*Sculpture.*—On both sides are distinct transverse striæ, but no longitudinal striæ. The inner surface of the shell is smooth and does not show growth lines.

*Size* of the tube. Width at the aperture 14 mm. Shorter diameter at aperture 8 mm. Length of tube supposed to be about 50 mm. The lip projects above the tube about 5 mm.

*Horizon and locality.*—Assise E. 2 (a ?) at Young point near George river station, N.S.

This species has a sharper emargination at the lateral angle of the aperture than is shown for *H. tenuistriatus*. Billings speaks of a similar notch in his species *H. princeps*, but Mr. Walcott does not depict this feature in the examples he ascribes to Billings species. The Cape Breton species differs from *H. excellens*, Bill., in the sharper lateral angles of the tube, &c.

Besides this species there are fragments of the tubes of Hyolithes at three other horizons of the lower Etcheminian; they are, however, in poor preservation, and we have not been able to recognize the opercula of any form of this or the preceding genus in the Etcheminian rocks of Cape Breton.

In the Upper Etcheminian of this island we have not found the remains of any Hyolithidæ, though it is apparently in this part of the Etcheminian terrane that they occur at Smith's Sound in Newfoundland. The genus Orthotheca is exhibited there in great variety. On that sound the Etcheminian beds consist of fine argillaceous sediments of a red color, with some thin limestone beds, while in Cape Breton the Hyolithes-bearing beds are mostly coarse and sandy and abound in effusive volcanic materials. The difference in the genesis of the sediments in the two regions may account for the perfect condition of the fossils in the one, and their fragmentary state in the other.

### *1.—Development of the genera Acrothyra, Acrotreta and Acrothele.*

The value of small species of fossils in determining geological horizons is well shown in Tullberg's monograph on the Agnosti, of which genus certain types are peculiar to special horizons of the Cambrian and of the Ordovician. A small fragment of rock only has been found sufficient, when containing certain Agnosti, to determine the age of a group of strata.

I hope it may hereafter be possible to use the three genera above mentioned in a similar way for determining the age of parts of the Etcheminian and the higher Cambrian, where these genera occur. It is as a contribution to this object that the writer presents here descriptions of such species and varieties as have been recognized in the Canadian Cambrian rocks.

It will be seen that so far as our knowledge goes, the first two genera are among the oldest that have been recognized in the Cambrian rocks of Eastern Canada, since they are found along with the volcanics that lie at the base of the Palæozoic terranes, as well as higher up in the Cambrian; and they were distinct from each other, even at that early time.

The following table shows the distribution of these early forms of Brachiopods in the Basal Cambrian rocks and their relative abundance at Dugald brook at the several horizons at which they occur:

## Distribution of Acrothyra and Acrotreta in the Coldbrookian and Etcheminian of Cape Breton.

Distribution to Acrothyra and Acrotreta in the Basal Cambrian.

| These species and mutations are described in the following pages. | Coldbrook. | Etcheminian. | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | | | | 2 | | 3 | | | | |
| | | *a* | *b* | *c* | *d* | *a* | *b* | *a* | *b* | *d* | *e* | *f* |
| Acrothyra signata | .. | .. | **7** | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| —— —— prima | 18 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| —— —— sera | .. | .. | .. | 59 | .. | .. | .. | .. | .. | .. | .. | .. |
| —— —— tarda | .. | .. | .. | 6 | 24 | .. | 1 | .. | .. | .. | .. | .. |
| —— —— orta | .. | .. | .. | .. | .. | .. | .. | 3 | .. | .. | .. | .. |
| A—— proavia | .. | .. | .. | .. | .. | .. | .. | .. | .. | 6 | **160** | .. |
| A—— —— prima | .. | .. | .. | .. | .. | .. | .. | 7 | .. | .. | .. | ?1 |
| A—— —— crassa | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | 1 | ?1 |
| Acrotreta papillata | .. | .. | .. | 2 | **25** | .. | .. | .. | .. | .. | .. | .. |
| A—— —— prima | 1 | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| A—— sp. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |

N. B.—The figures in the columns show the number of individual shells examined. The horizons where the *types* of these species are found are marked by heavy faced numbers. Only the ventral valves are recorded in this table.

## ACROTHYRA.

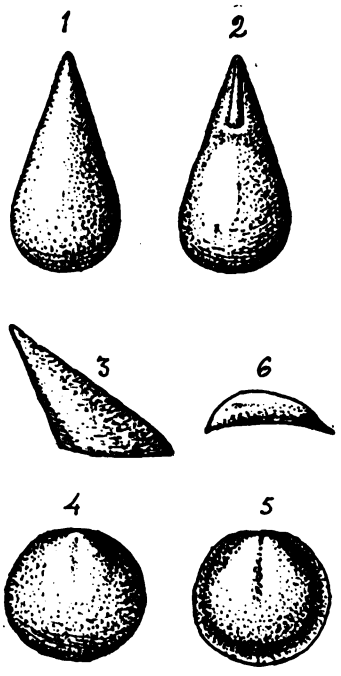
The genus Acrothyra.

In studying the earliest strata of the Eo-Palæozoic of the island of Cape Breton in Nova Scotia, Canada, the author has met with a form already described in the pages of the Bulletin of the Natural History Society of New Brunswick as an Acrotreta,* but which, from more perfect knowledge of the shape, habits and structure, he now thinks should be set off as a separate genus with the following characters:

Quite small Brachiopods having the ventral valve elongate-conical, with the apex either overhanging the cardinal line, or but little in front of it. Orifice nearly circular, often oblique. *Interior* with a long, narrow, or a quadrate visceral callus, extending forward from the foramen about a third of the length of the valve and widening as it goes.

*Acrotreta proavia, Bulletin of the Natural History Society of New Brunswick, vol. iv., p. 203.

A distinct, usually high, cardinal area extends from the foramen to the cardinal line.




*Acrothyra proavia*, mut. *prima*—1, Ventral valve—2, Mould of the same—3, Same in profile—4, Dorsal valve–5, Mould of the same-6, Same in profile. All magnified $1\frac{1}{2}^{0}$ Upper Etchemin Shale, C. Breton, N. S.

Dorsal valve as in Acrotreta.

The difference in the form of the ventral valve distinguishes this genus from Acrotreta and is accompanied by difference of habit, etc. In Acrotreta the visceral callus is concentrated around the foraminal passage, and the shell appears to have been of sedentary habit, since the ventral valve in many cases is found fossil in such an attitude as to show that it stood in a vertical position in the mud of the sea bottom when the animal which inhabited it was living, the opening of the valve being uppermost. No such uniformity of attitude characterizes the dorsal valve.

We find that the ventral valve in Acrothyra assumes quite a different attitude. It lies in very many cases on its side, and usually with the opening of the valve uppermost. Moreover it is to be noted that on successive layers these valves lie with the umbo oriented in a fixed direction. From this it may be inferred that they give evidence herein of the action of a current, flowing in a definite course and sweeping the valves in the direction towards which the current set. They may have swung in this direction by the pedicle while the animal was living; or when swept away by the flowing water, have presented the point of least resistance to the current, as they sank to the bottom. In either case we must regard Acrothyra as living under different conditions from Acrotreta, which, as we have remarked, apparently had the apex of the ventral valve buried in the mud. It is in accordance with these conditions that we have in Acrothyra a visceral callus developed along the median line of the ventral valve, as is the case in Lingula and other allied genera; and Lingula, as is well known, had a long pedicle.

ACROTHYRA SIGNATA. Plate I, figs. 2 *a-e*.

Bulletin Nat. Hist. Soc. of New Brunswick, vol. iv p. 377, plt xiii, figs. 2 *a-e*.

Acrothyra signata.

*Ventral valve*—Oval, pointed at the umbo, beak depressed and sides compressed. Hinge area oblique. *Interior.*—There is a strong narrow callus, one third of the length of the valve, bounded by a raised ridge at the sides and in front; at the front of this callus is an oval pit, from which a groove runs backward nearly to the apex of the shell, where it is supposed to connect with the foramen. Outside the callus, on each side, near the margin of the valve, are lenticular marks of the lateral muscles. About the middle of the valve the position of the anterior adductors is indicated by a faint impression of the lozenge or "heart-shaped" depression. The margin of the valve is thickened.

The *dorsal valve* is orbicular, strongly convex, and has a somewhat triangular appearence, because of the sides being depressed from the umbo, and because the front is strongly bent downward. *Interior.*—This shows a sharp, thin, median septum, for half of the length of the valve. This ridge is broader and more distinct at the front; at each side are lateral obscure ridges diverging from the umbo. Outside of these ridges are the lenticular imprints of the lateral muscles.

*Sculpture.*—The surface of this shell (which perhaps is not the real outer surface) is shining, and has fine concentric ridges visible only with a lens.

*Size.*—Length of the ventral valve, 3 mm.; width, 2 mm.; depth, ·1 mm. In the dorsal the length and breadth are equal, and the depth is less than that of the ventral.

*Horizon and locality.*—This species is found in Assise *b* of the lowest Etcheminian division at Dugald brook, a branch of Indian brook in Escasonie, N.S. On a cursory examination the ventral valve of this shell might pass for that of a Lingulella, but the closed deltidial area is that of Acrotreta and Acrothyra; the form of the dorsal and the nature of the interior show that the species is closely related to Acrotreta.

ACROTHYRA SIGNATA SERA. Pl. I, figs. 3 *a-f*.

Bulletin Nat. Hist. Soc. of the N. Brunswick, Vol. iv, p. 383, pl. xiii, figs. 3, *a-f*.

Acrothyra signata sera.

Valves corneous, thick, especially the ventral. General form orbicular, with the umbo of the ventral projecting.

*Ventral valve* nearly circular in outline, and with the back either straight, or slightly hollowed near the apex, and rounded down toward

the front margin. The margin is somewhat straightened at the hinge, and there is a depressed pseudodeltidium, with a narrow striate area on each side. The area is at right angles to the base of the valve, which, when viewed from the side, has the margin somewhat arched up at the front and back. *Interior.*—This has near the hinge a thick rectangular callus, hollowed at the middle, with a depression that deepens toward the hinge; from this it is divided by a low transverse ridge, behind which is a pit leading to the foramen, which is just behind the umbo. On each side of the callus, two low ridges extend forward at a wide angle, and limit the area occupied by the lateral muscle scars. The position of the central group of muscles in front of the callus is not clearly defined.

The dorsal valve is orbicular and the umbo depressed. Two broad obscure ridges radiate from the umbo to the sides of the valve. When viewed sidewise the valve is seen to be bent down both at the anterior and posterior ends. *Interior.*—The most prominent feature is the median septum, which is usually visible from one-sixth of the length of the valve from the back, to the middle of the valve. A pair of diverging grooves originate at the hinge line, and forward, towards the sides of the valve, divide off the space occupied by the impression made by the lateral muscles. Midway between these grooves and the median septum, are two faint vascular ridges. The margins of both valves are thickened and flattened.

*Sculpture.*—This consists of fine concentric ridges with smooth intervals between; the known surface is smooth and shining, but there are fragments of what appears to be an outer layer, with a dull, minutely granulated surface. The surface is often ridged with growth lines, especially toward the anterior margin.

*Size.*—Length and width of the valves equal, 2½ mm. The depth of the ventral is 1½ mm.; that of the dorsal, 1 mm.

*Horizon and locality.*—The Assise 1*c* of the Etcheminian at Dugald brook, Escasonie (C.B.) N.S.

racteris- chemi- enus.

This differs from the type in the shorter and wider shell, upright hinge area, wider visceral callus, and straighter back of the ventral valve. From *A. signata prima* in the more regularly conical form of the ventral valve. This genus is particularly Etcheminian, there being two species and several varieties or mutations in the strata of this age. It seems likely *Lingulella* (?) *inflata* of the Protolenus Fauna belongs to Acrothyra, if so, the genus ranges up into the base of the St. John terrane.

Conotreta, of Walcott, an Ordovician (Trenton) genus is a later development from the Acrotretoid phylum, differing in the form of the visceral callus, which is pointed in front, in place of expanding, as in Acrothyra. Analogy, however, would lead us to infer that this genus also was free-floating by a long pedicle, and not sub-sedentary, like many species of Acrotreta. This type of Brachiopod—Acrothyra—is one of the earliest known in the Palæozoic rocks of Canada, being found in shaly layers in the midst of the eruptives which mark the advent of Palæozoic Time in Eastern North America.

Antiquity of the genus.

ACROTYRA SIGNATA—TARDA. Pl. II, figs. 1*a–d.*

Bulletin Natural History Society of New Brunswick, vol. iv. p. 364, pl. xiv, figs. 1 *a–d.*

Only the *ventral valve* known. This is tumid, with a broad low umbo, and convex on the median line. *Interior.*—Distinguished by two short prominent grooves that end abruptly, short of the end of the callus; the callus is narrow and has a low ridge along the middle; it ends 1¼ mm. from the hinge, and the two lateral grooves are about 1 mm. apart. Outside of the two grooves above named are low crescentic ridges in front of the lateral extensions of the hinge line, that enclose the scars of the lateral muscles.

Mutation tarda.

The *dorsal valve* has not been separated from that of *Acrotreta papillata*, which occurs with it.

*Sculpture.*—This, on the lateral slopes of the valve, consists of fine, closely set ridges, visible only with a lens.

*Size.*—Length, 2½ mm.; width, 3 mm.; depth, 1½ mm.

*Horizon and locality.*—In the gray shales of E. 1 *c* and *d* at Dugald brook, Escasonie, (C. B.) N. S. Common in the latter assise.

This mutation is distinguished from *Acrotreta papillata*, with which it is associated, by the form of the callus, etc.. and from *Acrothyra signata* (typical) by its flatter callus and deeper and shorter lateral grooves; the same characters distinguish it from *A. signata-prima* and *A. signata-sera.*

ACROTHYRA SIGNATA—ORTA. Pl. I, figs. 4 *a–f.*

Bull. Nat. Hist. Soc. of N. B., vol. iv, p. 385, pl. xiii, figs. 4, *a–f.*

This rather tumid form has an overhanging beak. *Ventral* valve broadly ovate, bluntly pointed, convex along the back, especially toward the front

Mutation orta.

of the valve, where the curve becomes abrupt. *Interior*—A callus about three times as long as its width in front, extending from the beak one-third of the length of the valve, sometimes there is an apophysis in front of it, of equal width, sometimes an apparent extension of the callus, with a median ridge dividing it lengthwise. The callus usually has a transverse raised thread towards the posterior end, and sometimes another near the front. A faint, narrowly triangular hollow, divides the callus from the impression of the lateral muscles.

The dorsal valve is oblately orbicular in form, with inconspicuous umbo. The valve is somewhat depressed in the middle and toward the front. *Interior*—This part of the valve exhibits a medium septum in the posterior quarter of the valve, and behind it two lateral septa, that fork from near the umbo; the place of the lateral muscles is faintly marked.

*Sculpture.*—Of fine concentric ridges, as with other forms of this species.

*Size.*—Length of ventral, 2 mm.; width, $1\frac{3}{4}$ mm.; height, 1 mm. to 2 mm. Dorsal length, $1\frac{3}{4}$ mm.; width, 2 mm.; height, about $\frac{1}{2}$ mm.

*Horizon and locality.*—Fine, greenish-grey calciferous sandstone of E. 2 *c.* at Dugald brook, Escasonie. Not rare.

This mutation shows a change in the direction of *A. proavia* of a higher horizon described below.

The ventral valves lie on their sides on the layers of the rock, but some dorsals are on edge.

ACROTHYRA PROAVIA. Pl. II, figs. 2 *a–g* and 3 *a–f*.

*Acrotreta proavia*, n. sp. Nat. Hist. Soc. N. B. Bull., Vol. iv, p. 203, pl. iii, figs. 2 *a* to *f*.; ibid, p. 386, pl. xiv, figs 2 *a–g*, and 3, *a f*.

yra
t.

Shell-substance calcareo-corneous. The thin outer crust sometimes wanting from corrosion, abrasion or absorption.

Ventral valve oblique conical, with a prolonged beak. Cardinal area narrow, as is also the pseudo deltidium; in the pseudo deltidium near the apex is a small oval tubercle, between which and the apex, the foramen is supposed to be situated. The valves slope evenly down from the apex to the anterior and lateral margins. No good examples of the exterior of this valve have been obtained; imperfect ones show two vascular lines enclosing a narrow visceral callus, and extending as far down from the apex on one side, as the hinge area does on the other; the front margin exhibits on the interior a row of about ten radiating vascular ridges

This valve is often undulate with one, sometimes several strong grooves concentric to the umbo, marking periods of rest in the growth of the shell: corresponding ridges are found on the deltidial area.

The dorsal valve is round, and broadly rounded in front; the contour of the surface is varied by a moderate projection of the umbo behind, and by a slight flattening of the valve in front, giving the valve a rounded, slightly triangular relief. The *interior* has the impression of a pair of muscles in the umbo, whence a low ridge extends forward across the valve. Not infrequently the edges of this valve are flattened, and one or more grooves, concentric to the umbo, marking stages of growth, indent it.

*Sculpture*.—A strong lens reveals a series of concentric striæ on the surface on some examples of this shell, there being about 20 in the space of a millemetre. Between these ridges a still stronger magnifier (1 inch objective) shows a fine granulated surface with occasional rows of coarser granules, parallel to the concentric striæ. On the inner, chitinous surface there is a similar ornamentation, but less distinct than that on the surface of the outer layer.

*Size*.—Length of the ventral valve in the largest examples, 3 mm.; width, 2 mm. The dorsal valves in both diameters is 2 mm. Depth of the ventral valve from the beak 1 ½ mm.; that of the dorsal at the middle, ½ mm. A great majority of the valves are smaller and of the size given in the original description.

*Horizon and locality*.—In the Assise *e*, common (and less common in *d* where it is larger) of the upper Etcheminian, Dugald Brook, Escasonie, Cape Breton. Very thin shells are found on the highway at V. McPhee's in Assise *e*.

There is a good deal of variation in the form of the ventral valves of this species. The majority are of the dimensions given, but sometimes the width of the valve is equal to the longest diameter. Also the concentric furrows of growth are in some examples so profound as to give the ventral valve, when slightly distorted obliquely, the appearance of a minute Raphistoma.

Attitude of the fossils.

This species differs from all others of the Acrotretinæ known to me, except *L. inflata* of the Protolenus fauna, in the high overhanging apex, which in the typical form projects one-quarter beyond the base of the valve, but in one variety from Assise *e*, one-third beyond. As a result of their form, the ventral valves of this species, in place of standing erect like many of those of the genus Acrotreta, rest on the dorsal side, on the layers of the shale in which they are imbedded, and except for their marked convexity

might be mistaken for those of a minute Lingulella. As they occur scattered over the layers of the shale they also strongly recall the ordinary aspect of the conical teeth of fishes, brilliant with black enamel.

No described species of Acrotreta is as small as the more abundant valves of this species, though *A. gemmulà* of the Protolenus fauna approaches it in that respect.*

Sir William Dawson has called attention to the resemblance in structure between the shells of Hyolithidæ and the Brachiopoda, and has compared the ventral valve of a Brachiopod to the tube of a Hyolithes. Had Sir William been acquainted with this species he would have found it a good example for comparison. This will be seen if the ventral valve be so oriented as to make the areal side correspond to the ventral side of a tube of Hyolithes. The dorsal valve with its round form and excentric umbo, with radiating lines, also resembles the operculum of a Hyolithes. A detailed comparison of this species with certain Hyolitidæ has been made in an article contributed to the Royal Society of Canada (Trans. New Ser. Vol. VII., Sec. IV. p. 93).

A study of layers of the shales of the horizon E. 3 *c*., studded with the valves of this species, failed to reveal any ventral valves, showing clearly a thickened callus. For the relationship of this species we have therefore to depend on the forms *prima* and *crassa*, both of which possess a narrow callus. These show that these three forms are of the same genus as *A. signata*, but of a different species, and reveal a series in the upper Etcheminian Fauna parallel to the *Signati* of the lower fauna ; they are distinguished from the latter by their narrow visceral callus. The absence of a thickened callus in the typical form of *A. proavia* would seem to show that the pedicle in this form was slender and weak, and from the fact that this shell, above all its fellows, shows a perfect orientation in one direction, as imbedded in the shale, there is a presumption that the pedicle was also long, enabling the animal to swing in the currents of the sea in which it lived. Often the ventral has an even slope along the back, but many old valves, especially long ones, show from two to three heavy concentric ridges, marking stages of the growth of the shells.

*Interior.*—The *ventral valve* of this species has a quite small tubercle in front of the foramen. Two-fifths from the apex of the ventral valve there is a shallow depression on the interior surface, which, by analogy with mut. *prima* should mark the position of the central muscle scar. On each side of the shallow depression a shallow groove runs forward toward the front of the valve. Some examples show a median and two lateral septa in front of the shallow depression. Faint ridges, run

* Trans. Roy. Soc. Can. Vol. xi, p. 87, pl. xvi, figs 2 *a* to *d*.

forward on each side of the front slope of the ventral valve, may indicate the position of vascular trunks.

*Interior.*—The *dorsal valve* has inside a median and two lateral ridges. On some valves the median ridge extends only so far as to divide the pits of the cardinal muscle; in others it extends to the middle of the valve. A pair of median pits are sometimes visible near the end of the median septum, one on each side of it.

ACROTHYRA PROAVIA–PRIMA, Pl. II, figs. 4 *a–f.*

Bull. Nat. Hist. Soc. of N.B. vol. iv, p. 389, pl. xiv, figs. 4 *a–f.*

*Ventral valve* triangular-ovate, about twice as long as wide, prolonged into a long pointed beak, and rounded and bent down in front. Mutation prima.

*Interior.*—This exhibits a long narrowly tapering callus originating in the beak at the foramen; the callus is a third of the length of the valve, or more. In front of the callus is a shallow transverse depression, marking the position of the central group of muscles.

The *dorsal valve* is nearly circular, projecting at the back, where there is a somewhat low beak, and rounded down more at the front than the sides. *Interior.*—A median septum is visible, dividing the pits of the cardinal muscles. A shallow median ridge traverses the middle of the valve, which is flattened at each side near the hinge. The edge of both of the valves are flattened and thickened, also the apical third of the ventral valve is thicker than the middle of that valve.

*Sculpture.*—This consists of a very fine granulation, with frequent, thread-like, concentric ridges.

*Size.*—Ventral valve: length, 3 mm.; width, 2 mm.; height of the cardinal area, 2 mm. Dorsal valve, 2 mm. in each diameter; depth, ½ mm.

*Horizon and locality.*—E 3 *a* = base of the upper Etcheminian shale at Dugald brook, Escasonie (C. B.), N. S. Frequent. In this rock the ventral valves of Acrothyra lie flat on the layers. Also a valve apparently of this form, 3 × 2 mm., from E. 3 *f.*, occurs at Gillis brook, a branch of Indian brook, Escasonie.

This mutation is distinguished from the type by its greater size and by the possession of a thickened callus.

ACROTHYRA PROAVIA–CRASSA, Pl. II, figs. 5 *a–c*.

Bull. Nat. Hist. Soc. of N. B. vol. iv, p. 389, figs. 5 *a–c*.

Only the *ventral valve* known. This is short, tumid and conical, *Interior.*—This possesses a narrow callus, four or five times as long as wide, and nearly a third of the length of the shell. At the front of the callus are two small oval scars divided by a faint septum. The callus is concave and extends back nearly to the beak.

*Sculpture.*—Some fragments of the surface which are preserved show fine, close set, concentric ridges.

*Size.*—Length, 2½ mm.; width, 2 mm.; height, 1½ mm.?

*Horizon and locality.*—Lower layers of the assise E. 3 *e*, at Dugald brook, Escasonie (C. B.), N. S. Also a doubtful ventral from E. 3 *f.* at Gillis, Indian brook, Escasonie. Scarce.

This mutation is distinguished from the type and from mutation *prima* by its robust form, and from *proavia*, the type, also by the possession of a thickened callus. From the mutations and type of *A. signata* by the narrowness of its callus.

Of the two species of Acrothyra herein described, *signata* was found specially to characterize the lower half of the Lower Etcheminian fauna, being found most abundant in the middle measures of this set of beds. It is not, however, limited to these measures, but by mutations is sparingly represented in the upper part of this lower fauna.

*Acrothyra proavia*, on the contrary, has been found only in the Upper Fauna, and mostly in its higher part, where some layers are crowded with thousands of these litte shells.

## ACROTRETA. Kutorga.

While this genus appears as a contemporary of Acrothyra in the earliest Basal Cambrian, it seemingly lived on after the latter had passed away. But throughout the Coldbrook and lower Etcheminian measures, it is quite subordinate in numbers to Acrothyra, and we have not found it at all in the upper Etcheminian. Throughout the true Cambrian in the Acadian Provinces, however, these conditions were reversed, for, with the doubtful exception of *Lingulella* (*Acrothyra*?) *inflata* of the Protolenus fauna, an undoubted example of the genus Acrothyra is unknown to me above the Etcheminian horizon, and Acrotreta has full possession of the field in the higher Cambrian zones.

ACROTRETA PAPILLATA, Pl. III, figs. 2 *a-f*.

Bull. Nat. Hist. Soc. of N. Bruns'k, vol. iv, p. 390, pl. xv, figs. 2 *a-f*.

(Calcareo-)corneous valves moderately arched, nearly orbicular, ventral valve with a moderately elevated umbo, one-fifth from the back of the valve; the back of the valve somewhat concave toward the umbo, but convex toward the front margin. There is a concave pseudo-deltidium, and the side slopes of the hinge area are convex. *Interior*—In this the visceral callus is short, sub-circular, and marked at the middle by a deep circular pit; at its sides, obscure, short, straight, diverging grooves are usually seen within the circular groove that surrounds it. Acrotreta papillata.

The dorsal valve is moderately arched, the slope being steepest toward the umbo, which is but slightly raised. On each side of the umbo flattened slopes run along the sides of the valve in the posterior half. There is a shallow median sinus on the beak of the valve, which widens toward the front. *Interior*—Under the beak is a boss from which a median septum runs forward, that forks about a fifth of the length of the valve from the hinge line; from the space between the forks, at a third of the length of the valve from the hinge, the median septum reappears, widens and terminates at a point nearly a third from the front of the valve. On each side of the umbo are pits of the cardinal muscles and outside these, in advance of them, and near the margin, are large scars of the lateral muscles.

The margins of both valves are flattened and thickened.

*Sculpture.*—This shell has a dull, minutely granulated surface, across which run narrow ridges concentric to the umbo, widely spaced in the middle of the shell, more closely arranged toward the margin, and closely crowded and narrow, on each side toward the hinge.

*Size.*—Ventral, 2½ mm. long, 2½ to 3 mm. wide, and 1¼ mm. high. Dorsal, as the ventral, except that the height is about ¾ mm.

*Horizon and locality.*—E. 1 *d*, the Gregwa shale of the Etcheminian at Dugald brook, Essonie, (C.B.) N.S. Common. It occurs also in Assise E. 1 *c*.

VAR. LATA, Pl. III, figs. 3 *a-c*.

Bull. Nat. Hist. Soc. of N. Brunswick, vol. iv, p. 391, pl. xv, figs. 3 *a-c*.

In examples from Boundary brook the form of the callus in the *interior* of the *ventral valve* varies from a perfectly circular elevation to one that Variety lata.

is somewhat squared at the sides; the groove outside of the callus is somewhat indistinct. On each side of the foramen is sometimes a short, sharp furrow directed forward. In the *dorsal valve* the depressed posterior lateral slopes and the somewhat flattened anterior slope give the valve a triangular appearance. The *interior* shows a pit at the hinge area, which is narrow, and thence a narrow median ridge runs nearly to the middle of the valve. An inconspicuous lateral branch is thrown off each side of the median ridge.

*Horizon and locality.*—The assise E. 1 *d*, on Boundary brook, Escasonie, (C.B.) N.S.

### Acrotreta. sp.

A species of this genus occurs in the sandstone of E 2*a* at Youngs point with *Lingulella Selwyni*. It is rare, and only a dorsal valve has been found.

### Development of Acrotreta.

opment rotreta.

This is one of the most conservative of the genera of the Cambrian and Ordovician. Though its species occur at intervals at various horizons in these Systems the uniformity of size and sculpturing is remarkable. Though so uniform as regards their outer surface, the various species of Acrotreta present differences of moulding of the interior of the valves, especially of the ventral valve by which they may be distinguished. This may be seen by consulting the figures of some of the Canadian Cambrian species given on plates iii, iv and xviii, where especially in the moulds of the ventral valves marked differences of form of the inside surface is apparent. As regards the moulds of the interiors of the dorsals also, the differences are sufficiently marked. (Compare with each other, figures 2*f*, 4*c* and 5*h* of plate iii, 2*g* of plate iv, and fig. 2 of plate xviii.) The ornamentation consists of a fine concentric striation, only visible with a strong lens. The size did not increase more than about four-fold in area in the vast space of time included in the Cambrian and Ordovician Systems. Contrast this with Paradoxides, which increased in area an hundred fold in the first two sub-faunas of the Paradoxides Zone. These sub-faunas perhaps do not cover more than a twentieth of the space of geological time represented by the range of faunas in the following table.

The series of Acrotreta run in size about as follows:

## Size and form of the Ventral Valve in Species of Acrotreta of the Cambrian and Ordovician

Table showing enlargement and change of form in Acrotreta.

| Horizon or Group. | Name and reference. | In Millimetres. | | | Proportion of Width to Height. |
|---|---|---|---|---|---|
| | | Length. | Width. | Height. | |
| Coldbrook Group. | A. papillata—prima, Pl. xv, figs. 1*a* to *c*.. | 2 | 2½ | 1¼ | 2. |
| Lower Etcheminian. | A. papillata, Pl. xv, figs. 2*a* to *f*..... | 2½ | 3 | 1¼ | 2.4 |
| Upper Etcheminian. ? | A. gemma, (Bill.) Walcott*... .. . .... | 2½ | 3 | 2 | 1.5 |
| Protolenus Fauna. | A. gemmula, † Pl. xv, figs. 4*a* to *d*... . | 1½ | 1½ | 1 | 1.5 |
| Lower Paradoxides. | A. Baileyi ‡ Pl. xvi, figs. 1*a* to *d*..... | 3½ | 4 | 1+ | 3.- |
| Upper Paradoxides. | A. socialis, v. Seebach,§..... . .... | 3 | 3 | 2 | 1.5 |
| Dolgelly, ? | A. gemma, (Bill.), Walcott*..... | 3 | 3½ | 2½ | 1.4 |
| Dolgelly, | A. bisecta,¶ Pl. xvi, 2*a* to *g*..... | 3 | 3¼ | 2½ | 1.3 |
| Tremadoc, | A. cf. socialis (Seeb), Brogger**..... | 1½ | 2 | 1½ | 1.3 |
| Tremadoc, | A. sipo, Pl. xviii, figs. 1 and 2..... .. | 3 | 3 | 2½ | 1.2 |
| Arenig, | A. gemma, Billings††. ..... | 1¾ | 2 | 2 | 1. |
| Llandeilo, | A. subconica. Kutorga'‡‡..... | 4 | 4 | 4¾ | .85 |
| " | A. Nicholsoni, Davidson, §§..... | 4 | 4 | 4¼ | .94 |
| Etage D. | A. babel, Barrande‖..... ..... | 2 | 2½ | 2¼ | 1.1 |

It will be noticed that not only are the later species as a rule larger, but they are proportionately higher. Also we may observe that there were two lines along which there was a divergence in the relative height of the ventral valve. *A Baileyi* had low umbones and approximated in form to Linnarssonia, a genus which, so far as has been observed, appeared in the Canadian Cambrian a little before it. The other and main line of development culminated in the high umboned species of the Ordovician faunas.

For information regarding several European species of Acrotreta I am indebted to Mr. Gilbert Van Ingen, of the School of Mines, Columbia College, New York.

* Bul. U. S., Geol. Survey No. 30, p. 98.
† Trans. N. York, Acad, Sci., No. XXVIII, p. 126.
‡ Trans. Roy, Soc., Can., Vol. III, Sec., IV, p. 36
§ Brachiopoda Paradox. Beds, Sweden, Linrs. p. 16.
¶ Nat. Hist. Soc., N. B., Bull. No. XIX, p. 275.
** Die Silurisch, Etagen 2und 3, p. 46.
†† Paleozoic Fossils, Vol. I, pt. 1, p. 216.
‡‡ Monog. Br. Brachiopoda, Vol I, pl. IX. Fischer, Conchyliologie p. 1266.
§§ Monog. Br. Brachiopoda, Vol. I. pl. XVI, Vol III, p. 338.
‖ Syst. Silur. Bohem, Vol. V, pl. 95.

## ACROTHELE Linnarsson.

### ACROTHELE AVIA. Pl. v. Figs. 1*a* to *f* and 2*a* and *b*.

ıele *Acrothele avia*, n. sp. Nat. Hist. Soc. Bull., vol. iv, p. 202, pl. iii, figs. *a* to *h*.

Bull. Nat. Hist. Soc. of New Brunswick, vol. iv, p. 396, pl. xvi, figs. 1 *a–f* and 2 *a–b*.

A rather large species with oblately oval valves and a thick horny shell.

Ventral valve somewhat concave in front of the apex. This valve has a triangular, somewhat convex, high area, including a narrow, slightly convex, pseudo deltidium, divided into two equal parts by an obscure central groove. There appears to be a foraminal opening at the slender pointed apex.

The *interior* of the ventral valve is marked by a shallow circular pit, on each side of the pedicle opening; and behind, at the margin, is a shallow triangular pit, resembling the pedicle groove of an Obolus. In front of the pedicle opening is a strong oval tubercle, on each side of which extend the ridges that bound the oval centre of the visceral cavity. Four low vascular ridges extend forward from this oval area to the anterior margin of the valve. The parts of the interior of the shell, above described, are enclosed by an ox-bow shaped groove, resembling the impression of vascular trunks; these trunks have about four anterior branches, and each trunk extends nearly to the front of the valve. On the lateral slopes of the shell are three crescentic grooves, which may be accidental and due to pressure.

The dorsal valve is strongly bent down behind and in front. The umb is slightly prominent, is appressed, and is close to the posterior margi The sides of this valve have about a dozen radiating, branching, crenulat ridges, that extend to the margin. The *interior* of the dorsal valve h a strong median septum, extending to the middle of the valve: at the e of this ridge is the central muscle. Scars of the latter are seen on ea side of the broad end of the median ridge, near its end. On each s of the median ridge at the cardinal margin are two pairs of muscle sc From the posterior part of the shell several faint radiating ridges ext toward the front margin.

*Sculpture.*—The surface of the valves is marked by irregular, con tric, rounded ridges, that frequently anastomose; and the front c ventral valve and the sides of the dorsal valve have a number of radi ribs. The sculpture is very variable; on the central part of the do shows an irregular network of low, rounded ridges; on the sides

valve these ridges are more regular in their course; and on the margins, especially of old shells, they are stronger and more continuous. There is also much variation in the distinctness of the features of the interior, both of the dorsal and ventral valves, the smoother shells being thinner. There is no trace on the interior of the dorsal valve of the ridges on its lateral slopes.

*Size.*—Length 9 mm.; width 10 mm. or more. Depth of the two valves together 2 mm. or more.

*Horizon and Locality.*—In assises *d* and *e* of the Upper Etcheminian (E. 3 *d* and *e*) Dugald brook, Escasonie, N.S.

Acrothele avia compared with other species.

As the outer layer of this shell is thin and fragile, the strong inner layer is the one most commonly exposed, and might be thought the real surface. The outer surface has an ornate sculpturing, while that of the second layer is smoothed. This species of Acrothele is distinct from all others by the long tubercle or callus in front of the pedicle opening. The ribs of the outer surface of the lateral slopes of the dorsal valve are peculiar to it. *A. Matthewi* and its varieties have no such ribs. *A. Matthewi-prima* has a granulate-latticed surface, but no lateral or anterior ribs. *A. Matthewi-costata* also has a granulated surface, and ribs on the front of the ventral, but none on the sides of the dorsal valve. The varieties of *A. Matthewi* also have the foramen nearer the cardinal margin than is the case with this species.

Examples of this species occurring in the Assise E. 3*d* differ from those of *A. abavia* occurring with it, in the thinner corroded valves, larger size and oblate form; they are doubtfully referred to this species for the ventral valve is more concave in front of the umbo than are the typical shells occurring in Assise E. 3*e*. It does not flake at the middle layer of the shell as *A. abavia* of the same assise does.

In Assise E. 3*d* valves appear, which, by their oblate form and surface markings, may, without much doubt, be referred to this species. Not only are they broader than the Acrotheles of the lower assises, but they are larger, some valves attaining 9½ mm. in width. An exterior of a ventral which is nearly one-half wider than long, and an interior of a dorsal about a third wider than its length, are figured.

In the examples from this horizon the *ventrals* show surface markings, hinge area and foramen; their interiors show crescentric grooves of the vascular trunks, and at the margin, prints of its branches. Some of the dorsals show the surface sculpture; others, which have the interior exposed, show median and lateral ridges, vascular lines, &c.

A. AVIA-PUTEIS. Pl. IV, figs 5 *a* and *b*.

Bull. Nat. Hist. Soc. of N. Brunswick, Vol. IV, p. 398, pl. XVI, figs. 5, *a–b*.

Variety puteis.

This seems to be a variety of *A. avia*. It differs in the possession of a pair of pits, one of which lies on each side of the space between the foramen and the visceral callus, partly overlapping each. The visceral callus is quite short in this form and has but little prominence. The ridges on the surface of the valve are more regularly concentric than in the type, and more sharply cut; about ten are found in the space of one millimetre. The cardinal area is curved forward towards the top, and finely striated. The foramen is about a fifth of the length of the valve from the cardinal line, and the front of the callus about a third. Vascular trunks and branches are visible on the surface of the ventral valve as in the type. The dorsal valve does not sensibly differ from that of *A. avia*.

*Size.*—The largest valve seen was 8 mm. long, and about the same width.

*Horizon and locality.*—Found in the Bretonensis shale (E. 3*d*.) at Gregwa brook, Escasonie, Cape Breton. Frequent.

ACROTHELE ABAVIA. Pl. IV, figs. 3*a* to *d*, and 4*a* and *b*.

Bull. Nat. Hist. Soc. of N. Brunswick, Vol. IV, p. 398, pl. XVI, figs. 3 *a–d*, and 4 *a* and *b*.

Acrothele abavia.

Outlines of the valve nearly circular. Length of the hinge line less than a third of the diameter of the valve.

*Ventral valve* rather flat, with the umbo slightly raised. The umbo is about one-quarter of the length of the valve from the cardinal line. *Interior.*—In the examples known from the horizon E 3*a*., the interior is smoothly moulded, except along the front slope, where faint vascular grooves may be detected, but in those from E. 3*b*., a visceral callus is faintly outlined, with a swelling on the middle; some valves here have faint impressions of vascular trunks on each side of the callus, running forward.

The *dorsal valve* has its greatest height near the middle, and has an appressed umbo, close to the hinge line; the lateral margins, in the posterior half, are revolute. *Interior.*—A median septum starting near the hinge line, extends across the middle of the valve to nearly one-third from its front; it is widest in the middle and fades away to a point in front. On each side of it is a vascular grove, the pair radiating from near the umbo and extending nearly to the front margin; they are nearly

as far apart at the front as half of the width of the valve. Another pair of such grooves, about half as far apart as these, are faintly impressed on each lateral slope of the valve. The visceral cavity is faintly marked out by striated lines in the posterior half of the valve, and has an irregular arched front, projecting near median septum towards the front of the valve. Faint vascular striæ are visible on the median area towards the front of the valve. Some examples from the horizon E 3 *b* have a shorter septum, and show the position of the central and lateral muscles closer to the hinge line. The shells are more oblate.

*Sculpture.*—This is only known near the side of the valve, where it consists of fine, closely set, more or less tuberculated ridges, parallel to the margin.

*Size.*—Length and width equal, 7 mm. Depth of the ventral valve about of a millimetre; that of the dorsal 1 mm.

*Horizon and locality.*—All the horizons from E. 3*a* to E. 3*e*, (except E. 3*d*,) at Dugald Brook, Escasonie, N.S.

The Acrotheles of E. 3*c* are much corroded, and do not show the characters well; they are mostly moulds from which the shell has been exfoliated. One ventral shows well the hollow behind the hinge area, and the foramen.

Examples from the assises E. 3*e*. have in the *ventral* valve quite a small tubercle in front of the foramen; the visceral callus extends half of the length of the shell, and at each side in front are sometimes seen pits of the adductor muscles: on each side of the callus a groove run out toward the front margin. Some examples show a median and two lateral septa in front of the callus. Often the shell has an even surface to the margin, but frequently there are a few strong concentric ridges that mark stages of growth.

This the oldest Acrothel

The dorsal valve of this species (from E. 3*e*) has inside, a median and two lateral ridges; on some valves the median ridge extends only so far as to divide the cardinal muscles; in others it extends to the middle of the valve. A strong pair of median pits are sometimes visible near the end of the median septum.

This is the oldest undoubted Acrothele detected in the Eopalæozoic rocks of Eastern Canada. Almost all show only the interior surface, or intermediate layers of the shell. One ventral has a corroded outside, with traces of concentric ridges.

ACROTHELE PROLES. Pl. v, figs. 3 *a* to *e*.

Bull. Nat. Hist. Soc. N. Brunswick, vol. IV, p. 400, pl. XVI, figs. 3 *a–e*.

General form lenticular with the umbo of the ventral valve projecting.

The length and breadth of the valves of this species are sometimes equal, though usually the width is somewhat greater.

The ventral valve is convex on all the slopes, except close to the umbo, where it is slightly concave in front. The umbo is low, and is about one-seventh of the length of the valve from the hinge line, the area is about 1 mm. long and the length of the hinge line nearly one-third of the width of the valve. *Interior.*—This has an obscurely lozenge shaped callus in front of the foramen, upon which at the posterior end is a small, more elevated portion. On each side of the callus is a pair of vascular ridges, marks of the advance of the central muscles. A pair of short ridges, near the hinge line, are of the nature of teeth outlining sockets for the articulation of the two valves. Faint curving ridges in the anterior part of the valve appear to be vascular trunks; these fork toward front, and show eight or nine ridges with corresponding depressions along the anterior margin.

The dorsal valve is more regularly lenticular, but more abruptly bent down behind than elsewhere, the umbo is depressed, and not easily recognized. Flattened valves exhibit costæ radiating from the umbo, but not reaching the margin. *Interior.*—This shows a strong, broad median septum extending nearly half of the length of the valve; at the front it fades away into fan-like ridges that rapidly sink to the level of the valve. On each side in the cavity of the valve, and extending nearly as far forward as the median septum and, diverging from it, is a pair of sharp vascular ridges. Outside of these, on the rounded edge of the valve, at the ends of the cardinal line, are a pair of elongated flattened teeth, that articulate with the sockets in the ventral valve. The margins of the dorsal valve are broad and rolled backward at the edges.

*Sculpture.*—This consists of fine, regular concentric ridges that occasionally anastomose. There are about eight or ten ridges in the space of one millimetre, the ridges being more widely spaced toward the margin.

*Size.*—The largest valve seen was 12 mm. long; valves of 9 mm. are common; the height of each valve is about 1 mm.

*Horizon and locality.*—In the shales of E. 3*f*., near the top of the Etcheminian at Dugald and Gillis' Brooks. Frequent.

This interesting species seems best represented in Europe by a specimen of Linnarsson, but that species is of the Paradoxides fauna. Resemblance of A. corrugatus to A. antiquus. Long its umbo is further from the hinge line and the cardinal features are different.

It will be noted that the supposed vascular trunks in this species, *Acrotheles corrugatus* and *Theca Walcottana Ferdinandea* are far removed from the margins of the valves.

## Acrotheles sp.

A species of this genus occurs in the flags of Division 2 (?) of the St. John Group at a cutting on the Intercolonial R. R. at Long Island passage, St. Andrew's Channel. The material is too imperfect to determine the species.

### *Notes on the following table.*

It seems quite probable that when the Acrotheles that have been described from the Lower Paradoxides beds are compared, some of the following names may be found to be synonyms, there being five species accredited to the Band c. But it is to be remembered that there are two sub-zones in this band, showing considerable differences in the fauna. To the lower sub-zone of Paradoxides lamellatus (*cf.* Olandicus) *A. granulata* and *A. cf. coriacea* are to be assigned, and to the higher or sub-zone of P. eteminicus, the other three.

As Mr. Walcott's species are referred simply to Lower Cambrian, one cannot compare them closely with the others; but it seems possible that the one referred to *A. subsidua* may be some other species, as it occurs with a different fauna than that of the original form, and apparently, by the stratigraphy, should be much older.

I have ventured to assign White's *A. subsidua* to the Paltura Zone, because it appears to be the same with a species which occurs in the Mt. Stephen Fauna; this fauna contains an Ogygia and an Olenoides with other forms which appear to indicate this as the lowest horizon to which it should be assigned. White's species is said by Director Walcott to occur with Asaphiscus and Olenoides, which also appear to be Upper Cambrian forms.*

Near the same horizon, or perhaps a little higher, would come Barrande's *A. incohans* which occurs in the 'Fauna of Hof' equivalent to the Tremadoc Fauna.

## Distribution of Acrothele in the Cambrian Rocks of Eastern Canada, etc.

| Number. | Name of Species and Reference. | Upper Etcheminian. | | | | | | St. John Group. | | | | | | | | | | | | | | Number. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Acadian. Division 1. | | | | Johannian. Division 2. | | | Bretonian. Division 3. | | | | | | | |
| | | Faunal Sub-zones. | | | | | | Faunal Zones. | | | | | | | | | | | | | | |
| | | | | | | | | Protolenus | | Paradoxides. | | | | | Parabolina. | Peltura. | Dictyonema Asaphellus. | Tetragraptus | | | | |
| | | *a* | *b* | *c* | *d* | *e* | *f* | *a* | *b* | *c* | *d* | *a* | *b* | *c* | *a* | *b* | *c* | *d* | *e* | | | |
| 1 | Acrothele abavia | × | | × | | × | | | | | | | | | | | | | | | | 1 |
| 2 | A. — — avia mut. puteis, m | | | | × | | | | | | | | | | | | | | | | | 2 |
| 3 | A. — avia | | | | × | × | | | | | | | | | | | | | | | | 3 |
| 4 | A. proles | | | | | | × | | | | | | | | | | | | | | | 4 |
| 5 | A. decipiens, Walcott | | | | I. C | | | | | | | | | | | | | | | | | 5 |
| 6 | A. Matthewi, mut. primat | | | | | | | | × | | | | | | | | | | | | | 6 |
| 7 | A. mut. letal | | | | | | | | × | | | | | | | | | | | | | 7 |
| 8 | A Gamagei, Hobbs | | | | | | | | | × | | | | | | | | | | | | 8 |
| 9 | A intermedia, Linnarsson | | | | | | | | | × | | | | | | | | | | | | 9 |
| 10 | A [illegible] Linnarsson | | | | | | | | | | | | | | | | | | | | | 10 |
| 11 | A [illegible] sp. ind | | | | | | | | | | | | | | | | | | | | | 11 |
| 12 | A [illegible] Bernardo | | | | | | | | | | × | | | | | | | | | | | 12 |
| 13 | A Matthew, Hartt | | | | | | | | | | ✓ | | | | | | | | | | | 13 |
| 14 | A [illegible] Linnarsson | | | | | | | | | | | | | × | | | | | | | | 14 |
| 15 | A [illegible] Walcott | | | | I. C | | | | | | | | | | | × | | | | | | 15 |
| 16 | A [illegible] Bernardo | | | | | | | | | | | | | | | | × | | | | | 16 |

Among the Acrotheles there are several types of sculpturing of the surface of the valves. The most characteristic is that of fine, short, irregular wavy ridges, such as are found in *A. Matthewi* and *A. granulata*. Another type is represented in *A. proles*, *A. gamagei* and *A. cf. coriacea* wherein the ridges become more regularly concentric; the valves in this group are larger, and the ventral less selliform than in the preceeding one. White's description of *A. subsidua* would indicate that there is a third style of ornamentation in the latter species, in which the surface is papillose, yet with concentric lines of growth.

Ornamentation of the surface of the valves in this genus.

From the time of its sudden appearance in the base of the Upper Etcheminian group, Acrothele continues to be common until we pass the Lower Paradoxides beds; from this point upward they are rarely met with in Eastern Canada. It is thus in Canada apparently more limited in range than Acrotreta, which extends up into the Ordovician. Its range also differs from that of Acrothyra, which is a common genus in the Lower Etcheminian, can be found even as far down as the Coldbrook, and also is present with Acrothele in the Upper Etcheminian, but hardly invades the Protolenus fauna; where, as well as in the Lower Paradoxides beds, shells of Acrothele are common.

Range of the genus in Eastern Canada.

Neither in Eastern Canada nor in Scandinavia do we find any Acrothele reported from the Upper Cambrian, but in these countries the fine dark ocean muds that were then accumulating were not favourable to the growth of Acrothele. Lindström however reported an undescribed species from the Ceratopyge limestone (equivalent to the Trunadoc Group of Wales) and from the occurrences in Bohemia and western North America it would appear that the genus extended up into the Ordovician or at least to its borders.

## LEPTOBOLUS, Hall.

Characteristics of Leptobolus.

At several horizons in the Etcheminian terrane we have met with small Brachiopods which seem to agree with Hall's genus above cited better than with any other. Such forms have usually been included in Lingulella, but in addition to their minute size they are separated from that genus by important characters.

These little shells have thin test, weak umbones; vascular trunks are situated near the lateral margins, and both the central and lateral muscle in both valves are advanced far toward the front of the valves. They are to be found both in sandy and muddy layers often mingled with Lingulella,

*Bull. U. S. Geol. Surv. No. 30, p. 40.

etc., though seeming to prefer a sandy bottom, in clear quiet water They abound in the Upper Etcheminian, and are spread vertically from the Coldbrook terrane to the summit of the Cambrian.

LEPTOBOLUS ATAVUS, Pl. VI, figs. 2 *a—g*.

lus *L. atavus*, n. sp. Bull. Nat. Hist. Soc., New Brunswick, vol. iv, p. 200, pl. ii, figs. 2, *a* to *f*.

A synopsis of the description of this species was published in the Bulletin of the Natural History Society of New Brunswick as above noted, a fuller description is the following:

Shell substance thin, calcareo-corneous. Valves somewhat quadrately oval to ovate; rather strongly arched transversely and behind.

Ventral valve somewhat pointed behind and having an inconspicuous umbo. Cardinal area very small and obscure, not more than one-seventh of the length of the valve. No pedicle groove has been determined, but the shell deepens suddenly in the interior behind the cardinal line. Except at the umbo the margins of the shell are strongly arched down. The *interior* shows at the side a pair of long lateral scars in the posterior half of the valve; extending from these scars forward are arching impressions of the vascular trunks. The scars of the central muscles are in the front half of the valve.

The dorsal valve differs from the ventral in the rounded posterior end and in the depressed longitudinal band which traverses the median part. The *interior* has a rhombic depression at the back, on the sides of which are placed the prints of a pair of muscle scars. Thence a narrow raised band extends along the median line nearly to the front. On each side near the middle of this band is a small muscle scar. Impressions of a vascular band extend along each side of the valve.

*Sculpture.*—Somewhat obscure, fine concentric striæ, visible with a lens, can be observed on all parts of the valve; there are about 15 to 20 in the space of a millimetre. But a strong lens will hardly resolve the finer ornamentation, which consists of a granulation, due to opposite series of striæ, crossing the shell diagonally. The second layer of the shell is smooth and shining, but having concentric ridges similar to those of the outer layer, without the minuter markings. Stronger growth lines occur at intervals of 6 to 10 of the concentric ridges.

*Size.*—Length, 5 mm; width, 3½ mm.; depth, 1 mm. Young individuals are proportionately wider, because in the later stages of growth additions are made chiefly to the front of the valve.

*Horizon and locality.*—In assises E. 3 *d* and *e* (Upper Etcheminian) at Dugald brook, Escasonie, &c.

The following table will show the size and salient characters of this species. The second, third and fourth columns give the dimensions of the valves; the fifth column, the length of the callus, in front of or near which the central muscles are placed; the sixth column shows the distance from the umbo of the principal growth furrows on the outer surface of the valve, which mark resting stages in the growth of the shell, the main furrow is usually at the front of the visceral cavity; the seventh column indicates the height of the hinge area; and the eighth column the space between the impressions of the vascular trunks.

DIMENSIONS of Leptobolus atavus from Assise E. 3 *e*.

| | Number. | Length. | Breadth. | Depth. | Callus. | Resting Stages. | Hinge. | Trunks. | |
|---|---|---|---|---|---|---|---|---|---|
| | | mm. | mm. | mm. | mm. | mm. | mm. | mm. | |
| Ventral valves. | 1 | 5 | 3 | 1 | ... | 2½ 3½ | ... | 2½ | Exterior! exfol'd. |
| | 2 | 4½ | 2¾ | 1 | ... | 3½ | ..... | 2¼ | " sculp. corrod. |
| | 3 | 5 | 3 | 1 | 2 | 4 | ¾ | 2 | Interior. |
| | 4 | 5 | 3 | 1 | ..... | 3½ | ¾ | 2 | " |
| | 5 | 5 | 3½ | 1 | ..... | ... .... | ..... | ... | Exterior, sculp! |
| | 6 | 5 | 3 | 1 | 2 | 3½ 4 | ..... | .. ... | " exfol'd. |
| | 7 | 4 | 3¼ | 1 | ..... | 3½ | ½ | ..... | " " widened. |
| | 8 | 5 | 3 | 1 | ..... | ..... | ..... | ..... | " sculp., corrod. |
| | | 38½ | 24½ | 8 | 4 | 2½ 17½ 8 | 2 | 8¾ | |
| | | 4·8 | 3·1 | 1· | 2· | 2·5, 3·5, 4 | ·7 | 2 2 | Average. |
| Dorsal valves. | 1 | 5½ | 3 | 1 | 3½? | 3½ | .... | ..... | Mould of inter. narrow? |
| | 2 | 4½ | 3 | 1 | 3½ | ..... | ½ | .... | " " broaden'd |
| | 3 | 5 | 3 | 1 | . . | 3½ 4 | ..... | ..... | Interior. |
| | 4 | 4½ | 2½ | 1 | 3½ | 2½ 3½ | ..... | ..... | Exterior, sculp! |
| | 5 | 4 | 2 | ¾ | 2½ | .... . .. | ½ | 1½ | Interior! |
| | 6 | 5½ | 3½ | 1 | ..... | ..... | ..... | .... | Mould of exterior. |
| | 7 | 5 | 3 | 1 | .... | ..... | ½ | .... | Exterior, sculp! |
| | 8 | 4 | 2½ | 1 | 3 ? | 3½ | ¾ | 2 | Mould of interior. |
| | | 38 | 22½ | 7¾ | 16 | 2½ 14 4 | 2¼ | 3½ | |
| | | 4.8 | 2·8 | 1· | 3·2 | 2·5, 3·5, 4· | ·6 | 1·7 | Average. |

Dimensions and features of the valves in assise E 3*c*.

The variation in form shown above is largely the resu
the shells after they were imbedded. The followin
form and other features of valves from the assise belov

DIMENSIONS of Leptobolus atavus from Assis

| | Number. | Length. | Breadth. | Depth. | Callus. | Growth Groves. | Hinge | Trunks. | |
|---|---|---|---|---|---|---|---|---|---|
| | | mm. | mm. | mm. | mm. | mm. | mm. | mm. | |
| Ventrals. | 1 | 5½ | 3 | 1 | ..... | 3½ 5 | 1 | 2 | Ir |
| | 2 | 6 | 3 | 1 | 2½ | 4? | 1 | ... | |
| | 3 | 6 | 3 | 1 | ..... | 3½ 5 | ..... | ..... | E |
| | 4 | 5½ | 3 | 1 | 3? | 3½ 4½ | 1 | 2 | Ir |
| | 5 | 6? | 3½ | 1 | 2? | 3½ | ..... | ..... | |
| | 6 | 5½ | 3½ | 1 | ..... | 4½ | ..... | ..... | |
| | 7 | 5 | 3 | 1 | ..... | .. ..... | .. ... | ..... | |
| | 8 | 6 | 3 | 1 | 3 | 4 5½ | ..... | 2¼ | |
| | | 45½ | 25 | 1 | 10½ | 22, 24½ | 3 | 6½ | |
| | | 5·7 | 3·1 | 1 | 2·6 | 4·4, 4·9 | 1 | 2·1 | A |
| Dorsals. | 1 | 5½ | 3 | 1 | 4 | 4 | 1 | 2½ | Ir |
| | 2 | 5 | 2¾ | 1 | ..... | 4 | 1 | ... | |
| | 3 | 5½ | 3½ | 1 | 4 | 3½ 4½ | 1 | 2½ | |
| | 4 | 5 | 3½ | 1 | 4 | 3 4 | 1 | 2½ | |
| | 5 | 5 | 3½ | 1 | 4 | 4 4½ | ..... | 2½ | |
| | 6 | 6 | 3½ | 1 | 4 | 4 4½ | 1 | .... | Ir |
| | 7 | 6 | 3½ | 1 | 4½ | ..... | ... | ... | |
| | 8 | 4½ | 2¾ | 1 | 3 | 4 | ..... | 2½ | E |
| | | 43½ | 25½ | 8 | 27½ | 22½, 17½ | 5 | 12½ | |
| | | 5·4 | 3·2 | 1 | 3·9 | 3·7 4·4 | 1 | 2·5 | A |

ıensions
characters
he valves
ssise E 3*d*.

In this assise the valves are larger, and proportionate
Assise E. 3 *e*.

ıpared
ı other
ies.

This species is of about the same size and geological a
*ferruginea*, Salt.; but if Davidson's figures are correct,
hinge area twice as long as this. It may be further obs
son has included in his species forms from much higher
brian (Dolgelly Group, &c), but the characters are so vag
oval species may be referred to *L. ferruginea*. We
dilemma of chosing between two, or several species whic
represent the species named, hence if one is *L. ferrugi*
not.

*Lingulella Granvillensis*, Walcott, of the New Yor
about the same size as this, and approaches it in form,
of the interior of the dorsal valve differs.

Mr. Walcott has borrowed from the writer the types of this species and of *Lingulepis Gregwa* for study and has decided that the former is the young of the latter.* While having the highest respect for Mr. Walcott's knowledge of Cambrian Brachiopoda, it may be well to present certain objections to this dictum. Not the young of Lingulepis Gregwa.

Students of the Brachiopoda will recognize that in Lingulella and allied genera the young stages are often round, when the adults become elongated by more rapid growth at the front than at the sides. In assuming *Leptobolus atavus* to be the young of *Lingulepis Gregwa* Mr. Walcott would reverse this law. Another objection to this decision is that *L. Gregwa* does not occur in the Assises E. 3 *d* and E. 3 *e*, where *L. atavus* is found but is much older; and on the other hand *L. atavus* in the typical form does not occur in the (Assise E. 1 *d*,) Gregwa shale. Other objections might be presented, but these are sufficient.

MUTATION TRITAVUS, n. mut. Pl. VI, figs. 5 *a–c*.

In the Lower Etcheminian another form which may be referred to this species is found. It is smaller than *L. atavus* or *L. insulæ* but proportionately wider; the edges of the valves have a radiating as well as concentric ridging. Mutation tritavus.

The following are the dimensions of some valves collected.

DIMENSIONS of Leptobolus m. tritavus from Assise E. 1 d.

| — | No. | Length. | Breadth. | Depth. | Callus. | Growth Grooves | Hinge. | Trnnks. | — |
|---|---|---|---|---|---|---|---|---|---|
| | | mm. | mm. | mm. | mm. | mm. | mm. | mm. | |
| Ventrals. | 1 | 4 | 2½ | 1 | 2? | 3½ | 1 | 1½ | Interior, mould. |
| | 2 | 4 | 2½ | 1 | 1½ | ..... ..... | .... . | 1¾ | Interior. |
| | 3 | 3½? | 2¼ | 1 | 1¼ | .. .. ... . | ..... | 1½ | Interior. |
| | | 11½ | 7¼ | 3 | 7 | 3½ | 1 | 4¾ | |
| | | 3·8 | 2·4 | 1· | 2·3 | 3·5 | 1 | 1·5 | Average. |
| Dorsals. | 1 | 4 | 2½ | 1 | 2½? | 2½ 3 | .. ... | .... | Interior. |
| | 2 | 4 | 2½ | 1 | . .. | 1¾ 3¼ | ..... | .. | Interior, mould. |
| | 3 | 4 | 2½ | 1 | ..... | ..... ..... | ½? | 1½? | Interior. |
| | | 12 | 7½ | 3 | 2½? | 1¾ 2½ 6¼ | ½? | 1½? | |
| | | 4· | 2·5 | 1 | 2½? | 1·7 2·5 3·1 | ·5? | 1·5? | Average. |

Dimensions &c of this form.

*Proced. U.S. Nat. Mus. vol. XXIII, page 694.

LEPTOBOLUS atavus, mut. INSULÆ, n. sp. Plate VI, figs. 4, *a*—*c*.

Mutation insulæ.

**Minute, shell thin, corneous or calcareo-corneous. Valves deep, elongate oval, having the edges rolled back. Ventral valve more pointed than the dorsal, having a small cardinal area where the shell is thickened, about one-tenth of the length of the valve.** *Interior.*—There is a lenticular cavity just in front of the hinge line. Visceral callus extending nearly to the middle of the valve; a faint transverse swelling is seen on some valves, half way from the beak. Grooves, that appear to be due to vascular trunks, but run along near the lateral margins of the valve. The dorsal valve approaches an elliptical form. It has a short area, with a tubercle on the axial line. *Interior.*—In front of the area is a transverse depression in which on each side is a pit, apparently for the attachment of the posterior adductors. The depression merges on each side into long, narrow lateral grooves (for vascular trunks?) like those of the ventral valve. The visceral callus extends across the middle third of the valve, where also on the axial line are low septal ridges.

*Sculpture.* This species has fine striæ, concentric to the umbo, over the whole shell.

*Size.* Length of ventral valve, $4\frac{1}{2}$ mm.; width $2\frac{1}{2}$ mm.; the dorsal is $\frac{1}{2}$ mm. shorter.

*Horizon and locality.* Assise E. 2, (*a*?) Lower Etcheminian at Young's Point. George R. Station, N. S. Scarce.

Compared to Lingulella linguloides.

This form is of about the same length as *Lingulella linguloides* of the St. John terrane in New Brunswick (which also appears to be a Leptobolus), but is proportionately narrower; it also resembles *L. atavus* of the Upper Etcheminian Fauna in form, but is considerably smaller and narrower and the callus of the ventral valve is proportionately shorter. The shell is very thin, and is flexible, as its valves are more distorted than those of the Lingulellas with which it is associated, and it is often moulded on the grains of sand with which it is imbeded. When the shell is distorted diagonally it may be mistaken for a small Ostracod, owing to the vascular groove which gives the margin the appearance of having a marginal fold, so often found in this group of crustaceans.

The following are dimensions of the valves of this mutation.

**Dimensions of valve of Leptobolus (mut.) insulæ. From assise E. 2 (a?).**

| | No. | Length. | Width. | Callus. | Growth of Groove. | Hinge. | Trunks. | |
|---|---|---|---|---|---|---|---|---|
| | | mm. | mm. | mm. | mm. | mm. | mm. | |
| Ventral Valves. | 1 | 4½ | 2½ | 2½ | ..... | ..... | ..... | Mould of interior. |
| | 2 | 4½ | 2½ | ..... | 3¼ | ..... | ..... | " " |
| | 3 | 4 | 2⅞ | ..... | ..... | ..... | ..... | " " |
| | 4 | 4 | 2½ | 2¼ | 3 | ½ | 2 | " " |
| | 5 | 4 | 2 | ..... | 2⅜ | ..... | ..... | " " |
| | 6 | 4 | 2 | ..... | ..... | ..... | ..... | Interior. |
| | | 25 | 14 | 4¾ | 9 | ½ | 2 | |
| | | 4·2 | 2·3 | 2·4 | 3 | 0·5 | 2 | Average. |
| Dorsal Valves. | 1 | 4½ | 2½ | ..... | 2—3 | ..... | ..... | Mould of interior. |
| | 2 | 4 | 2¼ | ..... | ..... | ..... | ..... | " " |
| | 3 | 4 | 2½ | 2¾ | 3 | ..... | ..... | " exterior. |
| | 4 | 3 | 2 | ..... | ..... | ..... | ..... | " interior. |
| | 5 | 3 | 2 | ..... | ..... | ..... | ..... | Interior. |
| | 6 | 3¼ | 1⅞ | 2½ | ..... | ..... | ..... | Mould of interior. |
| | | 21⅜ | 13¼ | 5¼ | 2—6 | ..... | ..... | |
| | | 3·6 | 2·2 | 2·6 | 2—3 | ..... | ..... | Average. |

Dimensions &c. of this form.

A comparison of the size and form of Leptobolus in the most typical group, gives interesting results. It shows a development in these Basal Cambrian rocks by an increase of the valves both in length and breadth, which is parallel to the development of Acrotreta in the Cambrian rocks, as a whole, as shown above, and in the writers paper on the Cambrian Acrotretidæ, etc.* This will be seen by the following table in which only the ventral valves are considered.

Development of the phylum of Leptobolus atavus in the Basal Cambrian rocks.

| | Length. | Width. | Proportion. | Area. |
|---|---|---|---|---|
| | mm. | mm. | | |
| Assise Co., homogeneous fine gray shale, *L. torrentis.* | 3·0 | 2·0 | 1·5 | 6·0 |
| Assise E. 1*d*, shale with volcanic sand, uniform marine current, *atavus*, mut. *tritavus*..... ..... | 3·8 | 2·4 | 1·6 | 9·1 |
| Assise E. 2 (*a*?) sandy shale, marine currents conflicting, *atavus* mut. *insulæ*. ... ..... .. . ... | 4·2 | 2·3 | 1·8 | 9·7 |
| Assise E. 3*d*, homogeneous gray shale, marine current uniform, *L. atavus* ..... ..... ..... | 5·7 | 3·1 | 1·84 | 17·7 |
| Assise E. 3*e* flaggy, more silicious shale, marine current uniform, *L. atavus*.. ..... ..... .. | 4·8 | 3·1 | 1·55 | 14·9 |

Development of the phylum of Leptobolus atavus.

*Additional notes on the Cambrian of Cape Breton, etc. Bull. Nat. Hist. Soc., N.B., vol. iv, p. 377, etc.

Of these five horizons, one is in the Coldbrook terrane, two in the Lower and two in the Upper Etchiminian faunal zones, and the gradual increase in size is quite noticeable. As far as the assise E. 3 *d*, there is a regular increase in the proportionate length of the valves, as compared with their width. But the return to flaggy and silicious beds reduces both the length and the superficial area of the valves. The layers of E. 3 *e* are crowded with multitudes of these little shells, which make up in numbers what they lack in size; while in the sandy layers of E. 2 (*a* ?) the shells of this genus are scarce; and notwithstanding the coarseness of the matrix are thin.

LEPTOBOLUS COLLICIA, Pl. VI, figs. 3 *a*—*e*.

*Leptobolus (?) collicia.* Bull. Nat. Hist. Soc. N.B., vol. IV, p. 200, pl. i, figs. 3, *a*—*e*.

Leptobolus collicia.

A small oval species somewhat pointed in front. Margins flattened, especially in the posterior half. Remarkable for the peculiar spoutlike flexure at the front of the dorsal valve, acquired in the later stages of growth. A corresponding pair of grooves appears in the anterior part of the ventral valve.

*Sculpture.* This consists of fine concentric ridges, visible only with the aid of a lens. These sometimes anastomose.

*Size.*—Length 10 mm., width 6 mm.

The peculiarity from which the name of this species was taken has been found to be a sporadic character; many valves do not have it.

The examples of this species first obtained, did not show clearly some of the essential characters of Leptobolus and the generic reference was left open. Examples obtained since then show that the conjectural generic reference was a right one: such as the forward position of the muscular scars and the grooves near the margin, supposed to be due to vascular trunks: this added to the regular oval form, fine sculpture, low hinge area, and similarity of the umbones of the two valves, are fair characters of Leptobolus.

Characters of the species.

*Leptobolus collicia* was a small species (though large for the genus), moderately tumid, oval, but somewhat pointed in front; margins flattened somewhat in the posterior half.

The ventral valve is pointed at the umbo, and has a very narrow apical slit or groove; it is evenly sloped to the margins, and, for a Leptobolus, rather flatly arched. There are two furrows or a depressed area in some examples, at the front of the valve. *Interior.* The callus is quite narrow, subtriangular, and about three-sevenths of the length of the valve. The lateral septa extend nearly half of the valve; they reach beyond the callus,

The dorsal valve is oval in form, and has a somewhat depressed band along the middle, for most of its length, but otherwise it is evenly sloped down to the margin; some examples are elevated along the middle in the interior quarter of the valve, forming a kind of spout at the front. The *interior* has a median band or callus extending three quarters of the length of the valve, and the lateral septa extend two thirds of its length; the marginal grooves (vascular trunks?) also show along this portion of the valve, and in front of it are forked. There are several fine ridges close together, along the median band, the two outer of which end at the mid-length of the valve.

*Sculpture.*—This, as mentioned in the original description, is of fine concentric ridges, of which there are about fifteen in the space of one millimetre; some examples have as many as twenty to a millimetre on the sides of the valves; these are crossed by close-set, minute, less conspicuous radiating striæ, that give a beaded appearance to the edges of the concentric ridges; there are also a number of growth grooves, marking resting stages in the growth of the valve.

*Size.*—Length 10 mm.; width 6 mm.; depth of each valve about 1 mm.

*Horizon and locality.*—In Assises E. 3 *c*, and *e*, Upper Etcheminian, at Dugald brook, and *f*, at Gillis' Indian brook, Escasonie, N.S.

The following are characters of the valves from the three horizons:

VALVES of Leptobolus collicia from E. 3 *e*.

| — | Number. | Length. | Width. | Callus. | Resting Stages. | Hinge. | Trunks. | — |
|---|---|---|---|---|---|---|---|---|
| Ventrals. | 1 | 6½ | 4½ | 3 | 4½ | .... | .... | Interior. |
| | 2 | 6+ | 4½ | .... | .... | .... | .... | No. 2 has closely set faint striæ; two faint ridges from the callus to the front margin. It is shortened by pressure. |
| | 3 | 7½ | 4 | 3½ | 4 5 | .... | ... | No. 3 is lengthened by pressure. |
| | | 20 | 13 | 6½ | 8½, 5 | .... | .. . | |
| | | 6·6 | 4·2 | 3·2 | 4·2, 5 | .... | .... | Average. |
| Dorsals | 1 | 6 | 4 | 3 | . . . | 1? | .... | No. 1 shows very fine striæ 20 to 1 mm. |
| | 2 | 6 | 4 | 4 | 4 | 1 | 3 | No. 2 mould of interior, shows callous and trunks. |
| | 3 | 6½ | 4 | 3½ | 4½ | 1 | .... | No. 3 elongated, mould, shows callus. |
| | 4 | 6 | 4 | 4 | 4 | ½+ | 3 | No. 4 mould of interior. |
| | | 24½ | 16 | 14½ | 12½ | 3½ | 6 | |
| | | 6·1 | 4·0 | 3·6 | 4·1 | 0·9 | 3·0 | Average. |

Dimensions &c. of valves in assise E 3*e*.

**Valves of Leptobolus collicia from E. 3 *c*.**

| — | Number. | Length. | Width. | Callus. | Resting Stages. | Hinge. | Trunks. | — |
|---|---|---|---|---|---|---|---|---|
| Ventrals. | 1 | 8 | 5 | 3¼ | 6 | 1½ | 3 | Interior and mould of same. |
| | 2 | 8 | 5½ | .... | 6 | .... | .... | No. 2. Sculpture of fine concentric ridges. Fine growth lines at intervals. |
| | 3 | 7 | 4½ | 3? | ..... | ... | .... | No. 3. Interior shows median sulcus at front. |
| | 4 | 8 | 5 | .... | .. .. | 1+ | .... | No. 4. Mould of interior. |
| | | 31 | 20 | 6¼ | 12 | 2½ | 3 | |
| | | 7·7 | 5·0 | 3·1 | 6 | 1·3 | 3 | Average. |
| Dorsals. | 1 | 7 | 4½ | 4 | ..... | 1 | .... | Mould, mascerated and wrinkled. |
| | 2 | 7+ | 5½ | 5+ | ..... | 1 | ... | No. 2. Hinge and visceral callus distinct. Sculpture, fine rather distant ridges. |
| | 3 | 6½+ | 5 | 4½ | 5 | 1 | .... | |
| | 4 | 7 | 4½ | 4½ | ..... | 1 | ... | No. 4. Mould shows cardinal area. |
| | 5 | 7 | 4½ | 5 | . ... | 1 | .... | No. 5 shows spout, visceral callus and hinge area. |
| | | 35 | 24 | 23 | 5 | 5 | .... | |
| | | 7·0 | 4·8 | 4·6 | 5 | 1·0 | ... | Average. |

**Valves of Leptobolus collicia from Assise E. 3 *f*.**

| — | Number. | Length. | Width. | Callus. | Resting stages. | Hinge. | Trunks. | — |
|---|---|---|---|---|---|---|---|---|
| Ventrals. | 1 | 6½ | 4½ | . .. | ..... | .... | .... | Surface corroded. |
| | 2 | 6 | 3½ | .... | .. . | .... | ... | " " |
| | 3 | 7 | 4 | 3 | ..... | .... | 2½ | Interior, callus has three ridges. |
| | 4 | 6 | 4 | 3½ | 4½ | ... | .... | Obscure sculpture. |
| | 5 | 6½ | 4½ | .. . | ..... | .... | ... | |
| | 6 | 7½ | 4 | .... | . .. | ... | 2½ | Interior, callus and trunks. |
| | | 37½ | 24½ | 6½ | 4½ | .... | 5 | |
| | | 6·6 | 4·1 | 3·2 | 4·5 | .... | 2·5 | |
| Dorsal. | 1 | 7 | 4 | 4 | 5 | 1 | 2½ | Surface corroded. |

Var., collis, n. var.

This is distinguished by its larger, broader and flatter valves. The dorsal valve has a longer callus; while, differing from the type, the lateral septa do not extend as far forward as the callus.

*Sculpture.*—Owing to the coarseness of the matrix, and the corrosion of the surface in the examples known, the ornamentation is very imperfectly preserved. Some examples show obscurely a fine concentric ridging; these ridges are much more numerous than those of *Lingulella longovalis* of the Lower Etcheminian Fauna which this somewhat resembles in form.

*Size.*—Length of the ventral valves 8½ mm.; width 5½ mm.; the dorsal is about 1 mm. shorter.

*Horizon and locality.*—Sandy gray shales of Assise E. 3*f.* at Gillis-Indian brook.

The following table will show the size and variation in form of a number of valves :—

VALVES of Var. Leptobolus collis in Assise E. 3*f.*

| | Number. | Length. | Width. | Callus' length. | Resting stages of growth.* | | Hinge, length. | Trunks, or part. | The dimensions given in this table are in millimetres. |
|---|---|---|---|---|---|---|---|---|---|
| Ventral valves. | 1 | 8½ | 5½ | 3½ | 5½ | 6½ | 1 | 3 | No. 1 shows several resting stages in the pedicle groove as well as on the outside of the shell. |
| | 2 | 7 | 5½ | ... | 5½ | | .... | 3 | No. 2 and No. 1 on the same slab have been differently distorted owing to difference in the orientation of the valves. |
| | 3 | 7 | 5½ | 3½ | 5½ | | | | |
| | 4 | 7½ | 4½ | 3½ | 4½ | | .... | 2¾ | |
| | 5 | 8 | 5½ | .... | ..... | | .... | 3 | No. 4 is narrowed by distortion. |
| | | | | | 6 | | .... | 2¾ | No. 6 elongated, shows vascular trunks well. |
| | 6 | 8½ | 5 | 4 | | | | | |
| | | | | | | 6½ | 1 | .... | No. 8 sculpture of fine concentric beaded ridges. |
| | 7 | 8 | 5 | 3½ | | | | | |
| | 8 | 7½ | 5½ | .... | ..... | | .... | .... | No. 9 broadened. |
| | 9 | 7½ | 5½ | 4 | 6 | | 1 | 2¾ | No. 10 shows traces of pedicle at pedicle groove. |
| | 10 | 8 | 5 | 4 | 6 | | 1 | 2¾ | |
| | | 77½ | 52½ | 26 | 39 | 13 | 4 | 20 | |
| | | 7·7 | 5·2 | 3·7 | 5·6 | 6·5 | 1 | 2·9 | Average. |
| Dorsal valves. | 1 | 7 | 5 | | 6 | | .... | .... | No. 1 macerated and wrinkled. |
| | 2 | 7 | 5 | .... | ..... | | .... | .... | No. 2 sculpture very fine beaded ridges. |
| | 3 | 6 | 5 | 4½ | 5 | | | | |
| | 4 | 7 | 5 | 4½ | 5½ | | 1 | 3 | No. 4 interior, shows muscle scars. |
| | 5 | 7 | 4½ | | | | | | |
| | 6 | 6½ | 4½ | 4 | 5 | | 1½ | 3 | |
| | 7 | 6½ | 4½ | | | | | | |
| | 8 | 6+ | 5 | 4 | 4 | | 1 | 3 | No. 8 broadened, mould of interior. |
| | 9 | 6 | 5 | | ..... | | .... | .... | No. 9 " |
| | 10 | 7 | 5½ | 5? | 5 | | 1½ | 3 | No. 10 " mould of interior. |
| | | 66 | 49 | 22 | 30½ | | 4½ | 12 | |
| | | 6·6 | 4·9 | 4·4 | 5 | | 1·1 | ·3 | Average. |

Leptobolus collicia-collis.

*The distance of each main cicatrice or resting stage, from the umbo, on the median line, is recorded in this and the following tables.

## LINGULELLA, Salter, 1861.*

rs of a.

When first studying *Lingulella Selwyni*, with much more defective material than has since been obtained,** it had seemed to the writer that there was a close relationship between the Russian species *O. Quenstędti* and species of the genus Lingulella. Messrs. Hall and Clarke had noticed the same.† Since then Michwitz has identified *O. Quenstedti* with *O. Apollonis*, the type of the genus Obolus, as a variety.‡ At a still later date, Director Walcott, of the U. S. Geological Survey, has followed up this line of investigation and has referred all Lingulellas to Obolus, as belonging to a subgenus of the latter.††

In support of this view, Mr. Walcott has marshalled much new evidence showing the close alliance between these two genera, but still to the writer there are objections to fusing the two. In the following description of the characteristics of *L. Selwyni* more complete than was possible a few years ago, some of these differences will appear, and this is a species desirable to use in this way, as it is particularly oboloid in aspect, from its broad cardinal area in the dorsal, its depressed beak, and other features. The horizon to which it belongs is far below that assigned to *L. Davisii*, the type of the genus Lingulella, and if one may judge by Salter's description of that species, this was smaller and deeper in the valves.

The types of Brachiopods which the writer in former articles has referred to Lingulella, in this report, he has divided into three groups Lingulella, Salter Lingulepis, Hall, and Leptobolus, Hall. The characters under which the two latter are separated are described under the two genera named and need not here be repeated or anticipated. Species, however, still remain under Lingulella, which are closely related to one or other of the above two genera (or sub-genera), that do not fully embody all the characters assigned to those two genera. Such forms are here still retained under Lingulella.

### LINGULELLA SELWYNI Pl. VII, figs. 1*a-c*.

*Linguella Selwyni*, n. sp. Trans. Roy. Soc. Can. 2d ser. vol. 1, pl. i, figs. 1 *a* and *b*.

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*In Memoirs Geolog. Surv. of G. Britain, vol. iii, 1880, p. 537, this genus appears to be accredited to S. Woodward, by Salter.

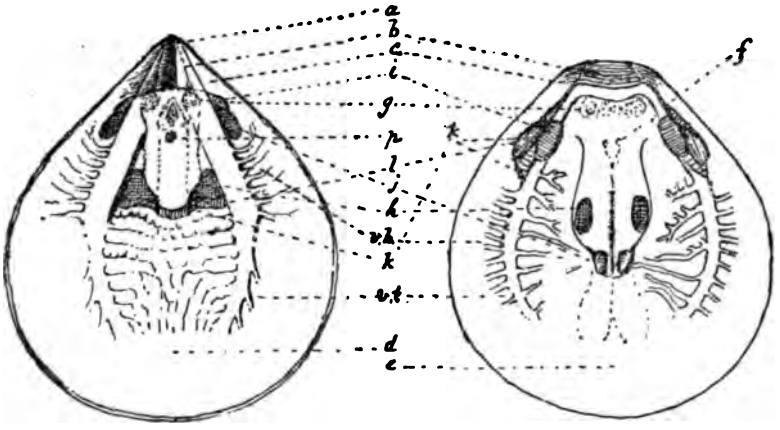
† Genera Palæozoic Brachiopoda, p. 337, figs. 38 and 39.

‡Mem. Imp. Acad. Sci. St. Petersb. Ser. 8, vol iv, No. 2, p. 79.

**Trans. Roy. Soc. Can., 2nd Ser., vol. i, sec. iv., p. 256.

††Proc. U. S. Nat. Mus., p. 390.

To show the anatomy of *L. Selwyni* the following figures have been drawn, enlarged four diameters from the original types. The pore pits with which the shells are studded and the radiating pits of the mantle rays are omited for greater clearness, but they are quite conspicuous on the valves. Lingulella Selwyni.




*Lingulella Selwyni*, enlarged 4 diameters to show musculation &c.

*a* Pedicle groove—*b*, pseudo-deltidium—*c*, cardinal area—*d*, excurrent branches of the circulatory system—*e*, front of the brachial area—*f*, small tubercles—*g*, cardinal muscle—?—*h*, anterior adductors ("central") muscle—*i*, transmedian muscles—*j*, anterior laterals—*k*, interior laterals —*l*, exterior laterals—*p*, pedicle muscle ?—*v.t.*, vascular trunks—*v.b.*, branches of the vascular trunks.

### VENTRAL VALVE.

*Cardinal area.*—This species has a well developed pedicle groove in the ventral valve, with slopes on each side descending to the deepened central depression, or groove. The pseudo-deltidium is rather narrow, and its sides slope inward as above described, the areal borders are narrow, and the striæ diagonal. The beak is depressed.

The striæ on the cardinal area cannot be due to the contact of the valves in this part as when fully grown the striæ of the last growth in the shell are depressed from $\frac{3}{4}$ to 1 mm. below the plane of the edge of the valve, and the corresponding depression on the dorsal valve would leave these two valves nearly two millimetres apart at the back, hence it seems probable that a ligamental (ileoparietal) band connected the

two and gave rise to the striæ that traverse this portion of the margin of the valves. If so, the valves of Lingulella may have had much less mobility than those of Lingula, and perhaps a different interpretation should be given to some of the muscle scars of Lingulella whose office and use are based on supposed analogues in the living genus Lingula.

*Muscle Scars. Cardinal and pedicle muscles.* There is great difficulty alve. in recognizing the imprint of the cardinal muscles; in a few valves very shallow round pits (*g*) on each side within the visceral cavity appear to represent the cardinal muscles. A little in front of the cardinal muscles on the median line, is a small lozenge shaped depression, which is separated by a low elevation from a small round pit, also on the median line, this pit (*p*) perhaps marks the point of attachment of the sinews of the pedicle muscle. From this small depression the thickened visceral callus, occupying the middle third of the valve, extends forward to the central group of muscles.

*Centrals*—These form, on each side of the front of the callus, a triangular group, consisting in each of a large posterior triangular print (*h*), and two smaller anterior muscles; of these the outer (*l*) is a narrow transverse triangular scar with the acute point of the triangle turned inward; the inner print (*k*) is rounder than the outer and somewhat posterior to it; it is obscure.

*Laterals.*—Two lateral muscle scars are imprinted at the side of the valve, near the hinge area. Of these the posterior and smaller, though outer (*i*) in the ventral valve, is supposed to mark the place of a transmedian muscle, the anterior and large (*j*), is the principal lateral muscle (unless the office of these two muscles is reversed).

ry *The vascular system*—Along the lateral margin in the posterior half of the shell, the imprint of the vascular trunks is straight; they diverge considerably and throw off numerous branches toward the margin of the valve. At the mid-length of the valve the trunks begin to converge, and on the outside throw off a few short branches, directed forward. On the inside of the trunks the branches are numerous; at first they are transverse, but farther forward the branches, especially in the central space, turn forward toward the opening between the extremities of the main vascular trunks.

## Dorsal Valve.

*Cardinal area.*—This is unusually wide for a Lingulella, and is distinctly striated transversely, the striæ arching forward in the middle; the areal borders are narrow and mark a change in the course of the striæ that traverse the back edge of the valve. A slightly raised ridge, like

a crescent, marks the division between the cardinal area and the visceral cavity. The middle of the cardinal area, at the hinge line, is three quarters of a millimetre below the sides, showing a depression here, as in the ventral valve, but much wider. Muscular system of dorsal valve.

*Muscle scars. Cardinal.*—Though there is a general depression at the back of the valve in front of the cardinal area, there is nothing which can with any certainty, be regarded as the imprint of a cardinal muscle. But there is a pair of narrow scars outside of and behind the group of lateral muscles that may have some office in connection with the hinge.

*Centrals.*—The group of central muscles is strongly marked and is situated at the middle of the valve. The centrals or anterior adductors, (*h*) are oval in form, and about as far apart as the width of the cardinal area. The anterior laterals (*j*) are about as far in front of the centrals as these are apart; they also are oval; are smaller and are closer together than the centrals. Between the two pairs of muscle scars of the central group, along the median line runs a sharp medium septum, with a narrow furrow on each side of it; in front of the anterior lateral scars the septum is replaced by a furrow.

*Laterals.*—At the back of the dorsal valve is a kind of angulated crescent, between which and the posterior end of the vascular trunks, the group of lateral scars are crowded together. On the line of the crescent on each side is a heavy oval scar (*i*); behind and outside of this is a small narrow scar supposed to be lateral (or cardinal); in front of this is a large scar, which like the one on the crescent is usually well defined, this is supposed to be the (*l*) lateral; an unimportant scar in front of this, which is sometimes seen is also supposed to be a lateral (*k*).

*The vascular system.*—The main trunks in this valve are farther apart than in the ventral and more strongly arched. The branches also are quite different in their course, etc.; the main interior branches are directed toward the central group of muscle-scars, and the outer ones radiate regularly toward the margin of the valve; the posterior inner branches throw off several spurs each, on the posterior side. Circulatory system.

Both valves have sinuses in the visceral cavity, those in the ventral narrow and angular, those in the dorsal broader, and rounded behind.

That there are important differences between Obolus and Lingulella will be seen from a comparison of the diagram of *O. Quenstedti* given by Michwitz with that of *L. Selwyni* as given above; these may be tabulated as follows :—

| Ventral Valve. | O. Quenstedti. | L. Selwyni. |
|---|---|---|
| Pedicle scar, relative to the cardinal muscle.. | Opposite. | Interior. |
| Transmedian scar | Interior. | Exterior. |
| Lateral muscle ( j ) | Exterior. | Interior. |
| Heartshaped area | Present. | Obscure. |
| Lateral muscle ( l ) relative to central (h) | Lateral. | Anterior. |
| Vascular branches | Sparse. | Numerous. |
| Vascular anterior, external branches directed | Outward. | Forward. |
| **Dorsal Valve.** | | |
| Posterior lateral ( l ) | Medium. | Large. |
| Position of central muscle (h) in the valve | Middle. | Behind middle |
| Anterior lateral ( j )—from the front of the valves | One-fifth. | Two-fifths. |

There may be some question as to the interpretation of the muscle scars of the dorsal valve of *Lingulella Selwyni* given in the preceding description, which is based on that of Lingula. But if it be assumed that the three principal posterior scars of the dorsal valve represent respectively *i*, *l* and *k*, the two latter will closely accord with those of Obolus; but then the posterior outer scar is without analogy in that genus, and the whole group is more closely crowded together.

Another distinction which appears to be of generic value is the position of the (*l*) lateral in the ventral valve. In *O. Quenstedti* it is at the side of the central scar (*h*), whereas in *L. Selwyni* it is at the front of this scar. In consequence of the different arrangement of the group of central scars in this valve in Obolus, the front outline of these scars curves away backward from the front of the visceral callus on each side, but in Lingulella it is transverse, or even turns forward from the front of the callus. It results that the whole group of central muscles in Lingulella is strongly triangular.

The following is the original description of this species quoted from Trans. Roy. Soc. Can. 2d Ser. vol I, Sec. IV. p. 255, pl. I, figs. 1*a* and *b*.

"LINGULELLA SELWYNI, n. sp., Pl. I, Fig 1*a* and *b*.

The form is sub-ovate, broadly rounded in front, but having nearly straight sides in the posterior half; the beak of the ventral valve is regularly pointed and that of the dorsal bluntly rounded. The ventral valve in its interior, exhibits two large, triangular scars, where the central muscles were attached, one on each side of the rhombic pit in the posterior third of the valve. The posterior adductors appear on each side of the hinge area, and there are sliding muscles, exterior to and in front

of them. In front of the posterior adductor muscle on each side of the valve, there is a low ridge extending forward as far as the scars of the central muscles: at and in front of these ridges the imprint of the main vascular trunks is visible, extending forward toward the median line.

The interior of the dorsal valve has a broad scar (posterior adductor?) just in front of the striated hinge area, and on each side of the hinge are impressions of sliding muscles. The central muscles are indicated by a group of small pits near the centre of the valve; of these the anterior adductors are oval and somewhat apart at the mid-length of the valve; the anterior adjustors are indicated by a pair of small rounded pits, a little in advance of those last named and closer together. A faint line (indicating the border of the splanchnocœle?) includes these scars and runs back towards the posterior part of the valve. Extending forward from near the cardinal area on each side are the lateral ridges and the imprint of the vascular trunks, as in the ventral valve, but here more distinct and bearing a number of branches directed, some inward and some outward.

*Sculpture.*—The external surface of the valve of this species is marked by fine concentric lines. and fainter radiating lines; there are also at intervals, concentric growth lines, and less distinct undulations of the shell, radiating from the umbo.

*Size.*—Dorsal valve. Length and breadth, each about 11 mm. The ventral valve is about 1·5 mm. longer.

*Locality.*—McFee's point, (*i. e.* Young point) George river, Cape Breton; collected by Messrs. Weston and Robert, of the Canadian Geological Survey.

The plan of the muscular scars of this species is very nearly that of *Obolus Quenstedti* of A. Michwitz, found in Esthonia, Russia, and as we find a shell in the Lower Cambrian of the St. John Group which possesses all the essential characters of an Obolus, but differs from this shell, we fully agree with Messrs. Hall and Clarke that *O. Quenstedti* could, with propriety, be excluded from Obolus; whether it should go into Lingulella will be better known when the internal features of the species *L. Davisii*, the type of that genus, are more fully described."

*Additional note on L. Selwyni.*

Additional characters of Lingulella Selwyni.

A comparison of the size and outlines of the valves of this species shows it to have been a wide one. The vascular trunks of the ventral valve are half as far apart as the width of that valve. This species has marked growth grooves on the outer surface, always outside of the

visceral callus, and most numerous on the ventral valve. The dorsal valve shows three grooves at an earlier stage than the ventral, but in the latter the grooves are more numerous and are most abundant toward the anterior margin; there are perhaps one-half more of these grooves on the ventral than on the dorsal valve; for often there is only one, and rarely more than two on this, but frequently three on the ventral. The following table shows the relation of these grooves to the length of the shell.

VALVES of L. Selwyni from Assise E. 1 (a ?)

(The dimensions given are in millimetres.)

| Ventral. | | | | | | | | | Dorsal. | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Number. | Length. | Width. | Depth. | Callus' length. | Resting Stages of Growth. | | | Trunks, apart. | Number. | Length. | Width. | Depth. | Callus, length. | Resting Stages of growth. | | |
| 1 | 12 | 13 | .... | 5 | 6 | ... | 11 | ... 6 | 1 | 10½ | 12 | 1½ | 6½ | .... | .... | 7½ ... .... |
| 2 | 12 | 13 | .... | 5 | 6½ | 8 | 10 | ... .... | 2 | 13 | 14½ | ... | 7 | .... | .... | .... 8 11 |
| 3 | 15 | 13 | .... | 7 | .... | 9 | .... | ... .... | 3 | 12 | 11 | .... | .... | .... | 6 | ... 8 .... |
| 4 | 10 | 14 | .... | 4½ | 7 | ... | 9 | 13 .... | 4 | 12 | 13 | .... | 8 | .... | .... | ... 8 10 |
| 5 | 12 | 13 | .... | 5 | 6½ | 8 | 10 | ... ... | 5 | 14 | 13 | | 8 | .... | .... | ... ... 10 |
| 6 | 13 | 11½ | .... | 4½ | .... | 8 | 10½ | 11½ 6 | 6 | 11 | 10 | | 7 | .... | .. | 7½ ... .... |
| 7 | 14 | 10½ | .... | . | . . | 8 | 11 | 13½ 5½ | 7 | 10 | 10 | | 5 | 5 | 6 | ... ... .... |
| 8 | 13 | 12 | .... | 5 | 7 | 8½ | 11 | 12 6½ | 8 | 11 | 12 | | 5 | ... | 6 | 7½ ... . |
| 9 | 12½ | 11 | 1½ | .. | 7 | ... | .... | 6 | 9 | 9 | 9 | 1½ | 4½ | 4½ | .... | 7 ... .. |
| 10 | 12½ | 10 | 1 | 5 | .... | ... | 10 | 5 | 10 | 11½ | 10 | 1½ | 6 | ... | 6 | 7½ ... .. |
| 11 | 12 | 11 | 1 | .. | 6 | ... | 9½ | .... .... | 11 | 9 | 9 | 1½ | 5 | .... | .... | .... .... .... |
| | 138 | 132 | 3½ | 41 | 46 | 49½ | 92 | 50 35½ | .... | 123 | 123½ | 12 | 62 | 9½ | 24 | 37 24 31 |
| | 12·5 | 12 | 1·2 | 5 | 6·6 | 8·2 | 10·2 | 12 6 | | 11 | 11 | 1·5 | 6·2 | 4·7 | 6 | 7 8 10·3 |

nsions of
lwyni.

*Sculpture.*—The umbonal region in this species is granulated. Outside of this region the granulation soon becomes varied by concentric striæ. In the anterior half of the valve, strong concentric furrows of growth, still further diversify the surface.

*Horizon and locality.* In the sandstones and sandy shales of the Lower Etcheninian rocks at Young point near George River station of the Intercolonial Railway, N.S. This fossil and its associates are provisionally assigned to Assise E. 2 *a*.

LINGULELLA TUMIDA. Pl. VI., figs. 6 *a*—*c*.

*Lingulella tumida* n. sp. Nat. Hist. Soc. Bull., vol. iv, p. 200, Pl. 1, fgs. 2 *a* to *c*.

The following is a fuller description of the species above cited.

Shell substance corneous. A small, round, thick-shelled species.

Lingulella tumida.

The ventral valve is broadly ovate, with a projecting beak, the valve is rounded down regularly on all sides to the margin. In the example figured the beak is broken away, and a mould of the cardinal area exposed; here a triple ridge rises abruptly to a slightly projecting elongated tubercle in the middle; it is the mould of a pit in the pedicle groove, similar to that in Obolus and Obolella.

The visceral cavity shows three grooves impressed upon it, of which the middle one, like the pedicle groove of the cardinal area, is triple. This valve is deepest in the posterior third.

*Sculpture.*—The surface of the shell is marked by rounded concentric ridges, some of which show a beaded crest.

*Size.*—Length, 6 mm.; width 5 mm.; depth 1½ mm.

*Horizon and locality.*—Assise E 3 *e*, Upper Etcheminian, Dugald brook, Escasonie, N.S.

This species in its general form approaches Obolus, but the strong projecting umbo separates it.

*Linguleпis Martinensis* of the Protolenus fauna is like this in form and surface markings, but is much larger. *Lingulella Ella* H. and W. of the Middle Cambrian of the West is like this in outline, but the surface markings are finer.

This species, *L. tumida*, is remarkable for the distinctness of the channels on the callus, due to the sinews of the pedicle muscle. Even in the pedicle groove these little grooves are seen.

LINGULELLA LONGOVALIS n. sp. Pl. VII., figs. 3 *a*—*f*.

Lingulella longovalis described.

A small elongately oval species approaching in form to Leptobolus. Ventral pointed, rather high along the median line in the posterior half; flatter toward the front margin. *Interior.*—The hinge area is

high, being about one-fifth of the length of the valve; the cardinal slopes and pseudodeltidium are of about equal width, and the latter is obliquely striated. The pedicle groove suddenly contracts in width toward the beak. The visceral callus is narrow and extends forward about half of the length of the valve; on each side of it runs a vascular line, marking the advance of the anterior adductors. On each side of the valve, half way between the callus and the margin, run the vascular lines that mark the advance of the lateral muscles; these extend nearly as far forward as the callus. The margins of the valves are flattened on the inside.

The dorsal valve is more obtusely rounded behind than the ventral, and in some examples is more tumid. *Interior.*—The height of the hinge area is about one-tenth of the length of the valve. The callus is quite long, extending four-fifths of the length of the valve; along the middle of the valve it is divided by a distinct median septum; the front of the anterior adductor scars is about one-third from the front of the valve; the lateral vascular ridges extend one-half of the length of the valve, from the hinge.

*Sculpture.*—This consists of wavy, beaded ridges, that sometimes anastomose; there are about eight in the space of a millimetre.

*Size.*—Length of ventral valve 9 mm.; width 6 mm; depth about $\frac{3}{4}$ mm. The dorsal valve is nearly 1 mm. shorter.

*Horizon and locality.*—In the shales of E. 1 *c* and *e*, Dugald brook, Escasonie, N.S.

As seen in Assise E. 1 *e*, this species is distinguished by its long oval form and the projecting beak of the ventral valve. The callus of the ventral valve is a straight narrow band, and the striæ of the hinge-area run a long way forward on the edges of the valves.

Compared with Leptobolus collicia.

This species in its oval form and elongated callus in both valves recalls Leptobolus, but the strong development of the hinge, the rather thick shell, and the coarse wavy ornamentation of the surface of its valves, seem to exclude it from that genus, as also the approximation of the vascular trunks in the ventral valve. Still it may be regarded as the representative in this fauna of *Leptobolus collicia* of the Upper Etcheminian.

Geological range.

It is not "satchel shaped", that is squared at the front and angulate behind, and so is not a typical Lingulella, but it is a common type of Lingulelloid shell, for similar forms are to be met with throughout the Cambrian system; it is among the oldest Cambrian types, being found in the Coldbrook volcanic terrane.

The following table shows the size and proportion of parts in a number of the valves of this species:—

VALVES of Lingulella longovalis from Assises E. 1 c and E. 1e.

FROM ASSISE E 1 *c*.

| — | (The dimensions are in millimetres.) Number. | Length. | Width. | Height. | Callus' length. | Resting Stages. | Hinge's height. | Trunks apart. | |
|---|---|---|---|---|---|---|---|---|---|
| Ventrals. | 1. | 9 | 6 | ¾ | 5 | 5½ | ..... | ..... | |
| | 2. | 8 | 5 | ¾ | 4 | ..... | 2 | 3 | |
| | 3. | 8 | 5 | ¾ | 4 | 6 | ..... | ..... | |
| | 4. | 8 | 5 | ¾ | 4 | 6 | 2 | 3 | |
| | 5. | 7½ | 5 | ¾ | 3¾ | 6 | 2 | 3 | |
| | 5. | 8 | 5 | ¾ | 4 | ..... | ..... | ..... | |
| | 7. | 8 | 5 | ¾ | 5 | ..... | 2? | 3 | |
| | 8. | 8 | 5 | ¾ | 4 | ..... | 2 | ..... | |
| | | 64½ | 41 | 6 | 33¾ | 23½ | 10 | 12 | Dimensions &c. of this species. |
| | Average. | 8·0 | 5·1 | 0·7 | 4 2 | 5·9 | 2 | 3 | |
| Dorsals. | 1. | 7½ | 6 | 1 | 5? | ..... | 1 | ..... | |
| | 2. | 8 | 6 | 1 | 4½ | 6 | ½ | ..... | |
| | 3. | 7½ | 5½ | ..... | ..... | ..... | ¾ | ..... | |
| | 4. | 6½? | 5 | 1 | 5 | ..... | ..... | ..... | |
| | | 29½ | 22½ | 3 | 14½ | 6 | 2¼ | ..... | |
| | Average. | 7·4 | 5·5 | 1 | 4.8 | 6 | ·7 | ..... | |

FROM ASSISE E 1 *c*.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Ventrals. | 1. | 7 | 5 | ¾ | ..... | 6 | ..... | ..... |
| | 2. | 8 | 5? | ¾ | 4½ | 5½ | ..... | ..... |
| | 3. | 7 | 4? | ¾ | 4½ | ..... | ..... | 3 |
| | | 22 | 14 | 2¼ | 9 | 11½ | ..... | 3 |
| | Average. | 7·3 | 4·6 | 0·7 | 4·5 | 5·6 | ..... | 3 |

## LINGULEPIS, Hall.

Characters of Lingulepis, Hall.

The late Professor James Hall described from the St. Croix Sandstones of the Mississippi valley a genus of Brachiopods, of which examples are found in the Lower Etcheminian Fauna, It is described as 'shells linguloid, inequivalve, equilateral, oval-spatulate or spatulate, muscular impressions in one valve (dorsal) flabelliform, in the other tripartite, the lateral divisions larger. Shell corneous, phosphatic. *Lingula pinni formis*, Owen, sp. is the type.

Hall's figure represents the callus as extending one half of the length of the ventral valve, and a little more than half of the length of the dorsal. Walcott makes this species synonymous with *L. acuminata*, Conrad, from the Potsdam sandstone; in this the callus of the ventral valve extends two thirds toward the front and that of the dorsal also to this distance. The Etcheminian forms carry out the feature observed for others of its genus, viz.: of a long callus to the dorsal valve; this, in the species named below, is proportionately longer than in the last named species and much longer than in the other. Valves of this genus are common in some portions of the Lower Etcheminian, but none have been found in the Upper. We have found no flabelliform impression in the dorsal valve, such as Professor Hall described for the type of the genus; nor in the ventral, lateral septa exceeding the callus in length.

### LINGULEPIS GREGWA. Pl. IX, figs. 3 *a–f.*

Lingulella Gregwa, n.sp. Bull. Nat. Hist. Soc. of N.B., vol. iv, p. 199, pl. I, figs. 1 *a* to *f*.

Valves pentagonally oval except for the long projecting beak of the ventral valve.

Lingulepis Gregwa described.

Ventral valve with a long somewhat acuminate apex, the rest of the valve evenly rounded. Deltidial ridges scarcely distinct from the areal border; both are crossed by striæ directed forward toward the pedicle groove. The *interior* of this valve has the group of central scars well forward, and shows impressions of vascular trunks, arching toward the front margin.

The dorsal valve is pentangular ovate and more strongly arched longitudinally than the ventral. The *interior* of this valve is remarkable for the very advanced position of the central group of muscles, which are about one-third from the front of the valve; this gives the raised band on which they are placed a ribbon-like appearance. The pits of the umbonal muscles and the posterior laterals are visible on the interior of this

valve, and two arched lateral impressions at the side of the valve are probably due to the vascular trunks.

*Sculpture.*—The valves in this species have a dull surface, which under the lens is resolved into irregular beaded ridges, concentric to the umbo, but often these ridges sink down, leaving a granular, or irregularly beaded surface.

*Size.*—Length of the ventral 14 mm. width 11 mm. The dorsal valve is 2 to 3 mm. shorter than the ventral ; depth of the two valves together about 3 mm.

*Horizon and locality.* In the gray shale of Assise E. 1 d. ; also a few valves in E. 1 b. and E. 1. c. Lower Etcheminian, Dugald brook, Escasonie, N. S.

Compared with other species.

This species has a long acuminate beak to the ventral valve like *Lingulepis pinniformis*, but the dorsal valve is different from the dorsal of that species ; its central group of scars is advanced far to the front as in Eobolus, and in connection with this, a flattened band traverses the centre of this valve, the flattened area is narrower than that of *Michwitzia monilifera* and *Obolus major* and it is a smaller species than the latter.

This species is like *L. acutangulus* Roem* of the Upper Cambrian of Texas, but is larger and differs in the more acuminate apex of the ventral valve, and in having the central muscle scars parallel to the long diameter of the valve. In the dorsal valve also the prints of the central muscles are much farther forward on the valve, and those of the posterior laterals farther apart.

*Lingulepis Gregwa* is a thin shell. In the species from Assise E. 1 c. only a thin chitinous layer is preserved, some moulds have not even that. No ventral valves were found in this assise.

In the Assise E. 1 *d.* at Boundary brook, the ventral, although acuminate, is blunted at the end, and the pedicle groove inside, rises gradually from the visceral cavity, without the ledge or shoulder often seen at the back of the shell in other species.

The above description covers the more salient characters of *L. Gregwa*, but larger collections made in 1901, enable me to add some particulars.

In the majority of individuals the sides of the ventral valve are straighter toward the beak, and the point is not so acuminate as representedin the figures (1*a* and *b*). Also the back part of the dorsal valve is more prolonged than as represented in the figures (1 *d* and *e*) ; so that there is not usually such a discrepancy between the length of the valves as 3 mm.

* Proc. Nat. Mus, U. S., vol. xxi p. 392, pl. xxvii, fig. 6 and pl. xxvii, figs. 1 and 2.

In Assise E 1 *d* as well as in the others mentioned, the valves are thin and they are flattened on the margins as seen in the shale. Being a thin shell it was more liable to distortion than others occurring with it, excepting perhaps the thin-shelled Leptoboli.

ice orna-ation.

*Sculpture* (additional note).—The surface of the valves is seldom preserved except near the beak. A variation from the dull granulated surface, where it is well preserved, consist of fine, somewhat irregular concentric shining ridges; these anastomose irregularly, or at times pass into an irregularly granulated surface. The dorsal valve shows the long callus with the muscle scars sometimes more, sometimes less advanced toward the front. The striæ of the cardinal area pass into the depression of the visceral cavity, so that they have no office of articulation, but appear to mark the line of attachment of a ligament or parietal band connecting the back of the two valves; such ligament or bond must have been divided on the ventral side for the passage of the pedicle. The connection of the two valves seems to have been very like that in Obolus.

The species exhibits considerable variation in form, as may be gathered from the following table.

VALVES of Lingulepis Gregwa in Assise E. 1 d., at Dugald brook.

| VENTRALS. | | | | | | DORSALS. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Number. | Length. | Width. | Proportion. | Area. | Groups. | Number. | Length. | Width. | Proportion. | Area. | Groups. |
| | mm. | mm. | | | | | mm. | mm. | | | |
| 1 | 12 | 11½ | 1·05 | 138 | ..... | 1 | 11 | 10½ | 1·05 | 115·5 | 100 |
| 2 | 13 | 10 | 1·30 | 130 | 100–130 | 2 | 10 | 10 | 1·00 | 100 | |
| 3 | 14 | 9 | 1·55 | 126 | | 3 | 10½ | 9½ | 1·11 | 99·9 | |
| 4 | 12 | 9 | 1·33 | 108 | | 4 | 10½ | 9½ | 1·10 | 99·8 | 80–100 |
| 5 | 11 | 8 | 1·38 | 88 | | 5 | 10 | 9½ | 1·05 | 95 | |
| 6 | 11 | 8 | 1·38 | 88 | 80–100 | 6 | 10 | 9½ | 1·05 | 95 | |
| 7 | 11 | 8 | 1·38 | 88 | | 7 | 8½ | 8 | 1·06 | 68 | |
| 8 | 10 | 8 | 1·25 | 80 | | 8 | 8½ | 8 | 1·06 | 68 | 59–80 |
| 9 | 10 | 8 | 1·25 | 80 | | 9 | 8 | 7½ | 1·07 | 60 | |
| 10 | 10 | 7 | 1·21 | 70 | 60–80 | 10 | 7 | 7 | 1·00 | 49 | |
| 11 | 9 | 7 | 1·29 | 63 | | | | | | | |
| 12 | 9 | 7 | 1·29 | 63 | | | | | | | |
| 13 | 9 | 7 | 1·29 | 63 | | | | | | | |
| 14 | 8½ | 7 | 1·21 | 59·5 | | | | | | | |
| | 149½ | 114½ | 18·16 | 1244·5 | ..... | ..... | 94 | 89 | 10·55 | 850 | |
| Average. | 10·7 | 8·2 | 1·30 | ..... | ..... | ..... | 4·9 | 8·9 | 1·05 | | |

ensions f valves Dugald

This table may be compared with the following of valves from another locality.

**Valves of Lingulepis Gregwa from Assise E. 1 d., at Boundary brook.**

| Ventrals | | | | | | Dorsals. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Number. | Length. | Width. | Proportion. | Area. | Groups. | Number. | Length. | Width. | Proportion. | Area. | Groups. |
| | mm. | mm. | | | | | mm. | mm. | | | |
| 1 | 12 | 9 | 1·33 | 108 | 100 | 1 | 11 | 9½ | 1·16 | 105 | 100 |
| 2 | 10 | 9 | 1·11 | 90 | 100—80 | 2 | 10½ | 9 | 1·16 | 94 | 100—80 |
| 3 | 11½ | 7 | 1·64 | 81 | | 3 | 9½ | 9½ | 1·00 | 90 | |
| 4 | 10 | 8 | 1·25 | 80 | | 4 | 10 | 9 | 1·11 | 90 | |
| 5 | 10½ | 7½ | 1·40 | 79 | | 5 | 10 | 8 | 1·25 | 80 | |
| 6 | 10 | 7½ | 1·33 | 75 | 80—50 | 6 | 9 | 8½ | 1·06 | 76 | 80—50 |
| 7 | 9½ | 7½ | 1·26 | 71 | | 7 | 9 | 8 | 1·12 | 72 | |
| 8 | 10 | 7 | 1·43 | 70 | | 8 | 8½ | 8 | 1·06 | 68 | |
| 9 | 9½ | 7 | 1·36 | 66 | | 9 | 8 | 7½ | 1·07 | 60 | |
| 10 | 9 | 7 | 1·29 | 63 | | 10 | 8 | 7 | 1·14 | 56 | |
| 11 | 9 | 6 | 1·50 | 54 | | 11 | 7½ | 7½ | 1·00 | 56 | |
| 12 | 9 | 6 | 1·50 | 54 | | 12 | 7½ | 7½ | 1·00 | 56 | |
| 13 | 7½ | 6 | 1·25 | 45 | | 13 | 7½ | 7 | 1·07 | 54 | |
| 14 | 7 | 6 | 1·17 | 42 | 50—30 | 14 | 7 | 7 | 1·00 | 49 | 50—30 |
| 15 | 7½ | 5½ | 1·36 | 41 | | 15 | 8 | 6 | 1·33 | 48 | |
| 16 | 6½ | 5 | 1·30 | 32 | | 16 | 7 | 6½ | 1·08 | 45 | |
| | | | | | | 17 | 6½ | 5½ | 1·02 | 36 | |
| | 148½ | 111 | 21·48 | 1051 | | | 144½ | 131 | 18·63 | 1135 | |
| Average. | 9·25 | 6·94 | 1·34 | | | Average | 8·5 | 7·7 | 1·09 | | |

Dimensions &c. of valves from Boundary brook.

The variation in the form of the valves in these two tables is, in many cases, due to the distortion of the valves after entombment.

If the remarks on orientation in an earlier part of this report be referred to, it will be seen that more than two thirds of the valves of this species both at Boundary brook and Dugald brook have been affected by orientation, and as this orientation is lengthwise of the valley of Indian brook of which these brooks are tributaries, that proportion of the ventrals are elongated beyond their natural form. In this table the ventrals average a third greater than their length; but they have been subject to the influence above referred to, and it may be assumed that in the original relation of form the length did not exceed the width by more than a quarter.

To this cause are traceable most of the extreme elongation of valves; but that there was a considerable variation naturally, is seen because valves oriented in the same direction show variation in comparative width and length. The length and width of the dorsal valve are so nearly equal that the effect of distortion and variation of form from biological

Remarks on the above tables.

causes is not so obvious, nevertheless the variability of the species is evident on examination of the accompanying tables. Ten valves from Dugald brook show an average of 5 p.c. excess of length, and seventeen valves, from Boundary brook an average of 9 p.c. The attitude of the valves has not affected their form in the same way as it has the ventral valves, as was explained in the remarks on orientation, and it may be assumed that the natural width and length of the dorsal valves of this species were about equal to each other.

Another fact noticeable in this connection is that only a few valves reach the full adult size. Also the shells from Dugald brook grew to a larger size than those from Boundary brook, where the measures of Assise E. 1 *d.* are more sandy. This is an unexpected result, as in later Cambrian terranes Lingulepis has been found especially to characterize sandstones. But it agrees with the habit of this particular species which, while rare and small in the earlier and more sandy assises of Division 1, became plentiful when the mud beds of Assise E. 1 d. were laid down (see annotation of species in the several assises p. 78).

Resting stages of growth.

*Cicatrices or resting stages in Lingulepis Gregwa.*—This species was apt to develope concentric grooves or cicatrices at certain stages of growth. Thus of eight ventrals from Dugald brook three show strong cicatrices at 7 mm. from the umbo and all show them at 9 mm., but not so distinctly. Of thirteen ventrals from Boundary brook twelve show grooves at 6 mm. from the umbo and eight show them, but not so well marked, at 8–9 mm. Of ten dorsals from Dugald brook, eight show a groove usually strong, at about six mm. from the umbo, and four show one at 8–9 mm. Of fifteen dorsal valves from Boundary brook, eleven show a groove, often strong, at about 6 mm. from the umbo, and three show weak ones at 8–9 mm. from that point. At both localities a few ventrals show resting grooves at 4 mm. from the umbo.

Allowing one to two millimetres for the extra length of the ventral valve these cicatrices on the two valves would come opposite each other. The deep ones are apt to be placed just outside of the visceral cavity of the dorsal valve, therefore considerably beyond the point of attachment of the central group of muscles of the ventral valve. The corrugation caused by these cicatrices would, no doubt, serve to strengthen these thin shells; yet we find some that have been decollated at this line, as the band of the visceral callus in a few valves has been found to extend quite to the front of the valve.

Mr. Walcott has made some curious mistakes in regard to this species.* First he places it as a species of the Paradoxides beds, when it actually

*Cambrian Brachiopoda, &c., Bull. U.S., National Museum, [illegible], pages 692-694.

occurs 1,000 feet below. Second he assumes that *Leptobolus atavus*, a shell quite different in form is the young of this species. Third that *Lingulella tumida*, a thick shelled species is also the young of *Lingulepis Gregwa*, which is thin-shelled. How the two named can be the young of this species seems difficult to understand, seeing that they occur in layers 300 feet above it, and that *L. Gregwa* does not occur in the layers with them, nor they in the lower horizon with it. These errors seem the more remarkable, since Mr. Walcott sent to me for these specimens for study, and they were distinctly marked as belonging to the Etcheminian terrane.

### Var. ROBUSTA, n. var.

Variety robusta.

Intermingled with the above species there are valves of a form nearly as large, which differs in its thicker and stiffer test, its more shining surface and straight posterior margins of the ventral valve (not incurved as in *L. Gregwa*). The concentric growth grooves are rare or weak in this form. It is placed here as a variety until better known.

The following table will show its relation to *L. Gregwa*:

VALVES of var. robusta from Assise E. 1 *d*.

| | Number. | Length. | Width. | Depth. | Callus' length. | Resting stages. | Hinges' height. | Trunks' apart. |
|---|---|---|---|---|---|---|---|---|
| | | mm. | mm. | mm. | mm. | mm. | mm. | mm. |
| Ventrals. | 1 | 10½ | 7½ | 1½ | 5 | 7 8½ 9 | 2 | 4 |
| | 2 | 10 | 6½ | 1½ | 4½ | 7 8 9 | 1½ | ..... |
| | 3 | 8½ | 6 | 1 | 4 | ... ... ... | ... | ... |
| | 4 | 9 | 7 | 1½ | 4½ | 7½ | 2 | ..... |
| | 5 | 10 | 7 | 1½ | ..... | ..... | ..... | 3½ |
| | | 48 | 34 | 6¾ | 18 | 21½ 16½,9 | 5½ | 7½ |
| | Average | 9·6 | 6·8 | 1·3 | 4·5 | 7·2 8·2,9 | 1·8 | 3·7 |
| Dorsals. | 1 | 10 | 7½ | 1 | 5 | 5½ 8 | 1 | 5 |
| | 2 | 7 | 6 | 1 | 4½ | 5½ | ½ | ..... |
| | 3 | 6 | 4 | ¾ | 3½ | 4 | ½ | .... |
| | 4 | 10 | 8 | 1 | 5 | 7 | ..... | ..... |
| | | 33 | 25½ | 3¾ | 18 | 22 8 | 2 | 5 |
| | Average | 8·2 | 6·4 | ·94 | 4·5 | 5·5 8 | ·7 | 5 |

Dimensions &c. of this variety.

LINGULEPIS ROBERTI Pl. VIII., Figs. 5 *a* and *b*.

The following species was described with *Lingulella Selwyni* in Tr
Roy. Soc. Can., 2nd Ser., vol. I, sec. iv, p. 256 :

"LINGULELLA ROBERTI, n. sp., Pl. I., Figs. 2 *a* and *b*.

epis
i
ed.

"Broadly ovate, the ventral value acuminate, having a low mesian r
in the posterior third, and slightly upturned at the beak. The d
valve tumid posteriorly, with a narrow hinge-margin, the valve h
mesian groove in the posterior quarter, and is flattened toward the fr
In the ventral valve the inner surface of the thickened posterior
of the valve carries two pairs of diverging ridges, the inner pair te
nating at the scars of the anterior adductors, of the outer pair about e
length, but continuous with impressions of the curving vascular tru

The dorsal valve also has in its interior four diverging ridges ; wi
the two outer ones at the back of the shell is the impression of the
terior adductor muscle ; and within the two inner ones, one-third
their ends, are the oval pits of the anterior adductors ; between t
scars, and extending backward in the valve, is a faintly marked m
ridge, placed about one-third from the posterior end of the valve.
pits of the anterior adductors diverge somewhat at their anterior
and a short distance in front of them are two small, round pits,
together, which mark the points of attachment of the anterior adju

*Sculpture.*—This consists of irregular concentric striæ which i
late with one another, producing a surface of broken ridgelets, sim
that of an Acrothele ; the concentric ridges are of unequal size, an
are occasional more distinctly marked growth-lines.

*Size.*—Length of the dorsal valve, 13 mm.; width about th
the ventral valve is about 1·5 mm. longer.

*Locality.*—Same as *Lingulella Selwyni*. Found in a sandy
of Assise E. 2 (a?) by Messrs. Weston and Robert.

This species is very little larger than *Lingulella Selwyni*,
tinguished by its radular ornamentation and thicker valves :
acuminate upturned beak, its tumid dorsal valve, and by the
the central muscular scars of this valve ; these scars are in t
half of the valve, but in *L. Selwyni* about the middle of the

This species approaches Lingulepis in the form of the
ventral valve, and in the advanced position of the lateral
dicated by the lateral septa.

From *Lingulepis Gregwa* it is easily distinguished by the short callus of the dorsal valve, and by the sculpture.

LINGULEPIS LONGINERVIS, n. sp. Pl. VII figs. 6, *a—g*.

A thickshelled species, with the dorsal somewhat, and the ventral valve greatly prolonged. Lingulepis longinervis described.

The ventral valve has an even arch to the anterior and posterior end on the axial line; it is more strongly arched down at the sides in the posterior half than elsewhere. The sides are straight from the umbo, beyond the middle of the shell, and thence regularly rounded. *Interior.* This shows a high hinge area, with very oblique striæ on the areal borders, and prolonged margin of the cardinal area, extending forward along the edge of the valve; the pedicle groove is deep and broad; the areal slopes have a great width near the umbo, and increase slowly in going forward. Extending from the hinge forward along the middle of the valve is a long visceral callus, on each side of which at the mid length of the valve are oval scars (of the central muscles?); in front of these and more approximated is a small pair of scars ("k" laterals?) The print of the laterals in these valves is heavy and extends nearly as far forward at the central scars; they are not as far from the central scars as these are from each other.

The dorsal valve is oval and has a low flat umbo; in most adult valves the posterior slope is strongly arched down, and the lateral slopes less so. The valve for most of its length is flattened along the median line. *Interior.* The hinge area is high and as in the ventral, the striæ of the slopes are quite oblique. There is a well marked long visceral callus extend to within an eighth of the front of the valve. The paired scars of the centrals are nearly two thirds of the length of the valve from the umbo, and those of the "j" laterals of adult valves less then one quarter of the length of the valve from its front. The laterals "l" and "k," are well shown in this valve, "l" being opposite the central muscles and "k" more advanced, smaller, and oblique; the above laterals are about as far from the centrals as these are apart. Traces of vascular trunks are seen inside of the laterals.

*Sculpture.*—Beside the concentric growth grooves, which are prominent on these valves, the lateral slopes display fine concentric ridges, about ten in the space of a millimetre; these little ridges are somewhat irregular in their course, and sometimes anastomose; elswhere they sink down so as to become rows of granulations; on the dorsal slope they merge into an irregularly rugose surface, across which run broken, radiating ridges, directed toward the front margin.

*Size.*—Ventral valve, length 11 mm.; width 8 mm.; depth, 1¼ mm. The dorsal valve is 2 mm., shorter than the ventral.

*Horizon and locality.*—Dark purplish gray sandstones of E. 2*b*, at Dugald Brook, Escasonie, N.S. Not rare.

The following table gives measurements of valves from this horizon :—

VALVES of Lingulepis longinervis from Assise E. 2 *b*.

| — | Number. | Length. | Width. | Depth. | Length of callus. | Resting stages of growth. | | | Hinge area. |
|---|---|---|---|---|---|---|---|---|---|
| | | mm. | mm. | mm. | mm. | mm. | mm. | mm. | mm. |
| Ventrals. | 1 | 9½ | 7 | 1¼ | . . . . . | 6 | 8 | | 2½ |
| | 2 | 11 | 8 | 1¼ | .... .... | | 8 | 9½ | . . . . . |
| | 3 | 9 | 6½ | 1 | 5 | 6½ | 8 | | . . . . . |
| | 4 | 10 | 7 | .. . . ... | 6? | 6 | 8½ | | . . . . . |
| | 5 | 9½ | 7 | 1 | ..... | .... ... ..... | ... | | ..... |
| | | 49 | 35½ | 4½ | 11 | 18½ | 32½ | 9½ | 2½ |
| | | 10. | 7· | 1·1 | 5·5 | 6 | 8· | 9·5 | 2·5 |
| Dorsals. | 1 | 9 | 8½ | 1 | 8 | .. ..... | .... | ... ... | ..... |
| | 2 | 8 | 8½ | 1 | 6½ | ... ... ... ... | | | 1½ |
| | 3 | 10? | 8½ | 1 | 8½ | | 9 | | .... ... . |
| | 4 | 7½ | 6½ | 1 | 6 | 6 | | | . . . . . |
| | 5 | 7 | 5½ | 1 | 6 | 6½ | | | .... . . |
| | | 41½ | 37½ | 5 | 35 | 12½ | 9 | | 1½ |
| | | 8 | 7·5 | 1 | 7 | 6·2 | 9 | | 1·5 |

This species is remarkable for the long large callus of the dorsal valve, and for the prolonged beak of the ventral valve. The average distance of the visceral callus of the dorsal from the front of that valve is only one-eighth of the valve's length. As the laterals of this valve also come far forward it may be assumed that the visceral cavity is unusually large.

*Obolus cœlatus* Volb. sp.* presents somewhat similar appearances in the dorsal valve, but its centrals are not nearly so far advanced. *L. (O.) acutangula*, Roem.† has points of resemblance in the ventral valve, especially in the prolonged beak, and oblique striae on the hinge area.

* Uber die Brachiopoden Obolus & Lingulella, Mem. Acad. Imper. Sci. St. Petersb., viii, ser. vol. iv, No. 2, pl. ii, figs. 21c. and 22c.

† Cambrian Brachiopoda, Obolus & Lingulella, U.S. Nat. Mus. Proc. vol. xxi, pl. xxvii, fig. 6.

There is a scarcity of growth cicatrices on the valves of this species; seldom are more than two seen on the ventral, and on the dorsal, one or none. This may be due to the advanced position of the muscle scars and the thickness of the shell.

## OBOLUS, Eichwald.

Genus Obolus how characterized.

"In default of more exact criteria, we have adopted here and elsewhere the following characters for distinguishing Obolus from Lingulella, viz: roundness of outline, short cardinal area and depressed beaks, advanced position of muscle scars in the valves, and strong arch of the vascular trunks in the ventral as well as the dorsal valve. (Sub-genus Palæobolus is an exception.) There is, however, a more important distinction, which, in consequence of imperfect preservation of the valves, can seldom be observed, that is, the position of the secondary muscles of the central group in the ventral valve, as compared with the great muscle of that group. In Obolus they are *lateral*, but in Lingulella *anterior* to the great muscle. This shows a radical difference of structure between the two genera." [Bull. Nat. Hist. Soc. N.B., vol. iv, page 198.]

There is also an important distinction in the advanced position of the scars of the "j" laterals in the dorsal valve of Obolus; in this genus they are placed toward the front of the valve, but in Lingulella they are not far removed from the centrals. As described by the Russian writers Obolus (sens. strict.) appears to range from the Dictyonema zone upward; it is, therefore, properly an Ordovician genus, while Lingulella is numerous in the Cambrian. For practical purposes (owing to difficulty in finding valvess howing the internal markings distinctly), it is convenient to use the diagnosis of Obolus given above, while at the same time it must be acknowledged that it is an unsatisfactory one. And the more so because wherever we have been able to find the internal markings of the Etcheminian Oboli they do not agree with the typical interior of Oboli obtained on the shores of the gulf of Finland. In this way we have come to recognize the fact that these Canadian Oboli, though similar in the form of the valves to the later ones of Russia, have had different origin. Of the two types that occur in the Etcheminian terrane, the older one in the arrangement of the central group of scars of the dorsal differs more from Obolus than that from Lingulella, and we have thought it necessary to establish a subgeneric distinction, as follow:—

## EOOBOLUS, n. subgenus.

Eoobolus new sub-genus.

In Obolus proper the anterior adductors of the dorsal valve are far apart and have a position at the mid length of the valve, while the "j"

laterals are far advanced to the front and are placed close together; in Lingulella the anterior adductors are also about the mid length of the valve, while the "j" laterals, approximated as in Obolus, are a little in front of these adductors; in Eobolus a third relation between thesemuscle pits is found; the group of muscles as a whole was in front of the centre of the valve, but the two pairs of muscles were almost or quite in line, longitudinally, with each other, and are arranged more or less in a quadrate manner. Beside these four pits of the central group, usual in the Linguloid Brachiopods, there is in this genus a fifth, being a small single scar on the axial line, sometimes equidistant from the other four and sometimes a little in front of the "j" laterals. This pit appears to mark a small muscle whose office is unknown.

The arrangment of the vascular trunks in this subgenus, so far as known, is similar to that in Obolus and Lingulella. This subgenus, Eobolus, characterizes the Lower Etcheminian Fauna.

OBOLUS TRIPARILIS n. sp. Pl. VIII, fig. 4 *a* —*c* and Pl. IX, figs. 1 *a* and *b*.

A lenticular, rather thick shelled species, the inside of the shell showing
E.) concentric rows of perforations like *Lingulella Davisii*.
s
d.

Ventral valve longer than wide, decidedly pointed behind, the part of the valve in front of the umbo, rather prominently raised and the slopes on each side depressed; valve somewhat flattened in front, elsewhere evenly arched. *Interior* not known, but there are indications that the callus extended as far as the middle of the valve.

Dorsal valve about as long as wide, somewhat flattened along the median line. *Interior.* A broad striated hinge-area lies across the cardinal end of the valve and runs forward on the lateral margins. Along the middle of the valve runs a long, raised callus, extending in some examples to within a quarter of the front of the valve, in others, less: this callus is about one fifth of the width of the valve; it is traversed lengthwise by a median and two lateral septa, of which the latter branch near the front, each branch, and the median septum extending respectively to three small muscle scars. Of the central group of muscle scars the two posterior are larger than the others which are of nearly equal size, and sometimes nearly equally advanced toward the front of the valve. A pair of vascular ridges extend out on each side of the valve nearly opposite to the central muscle scars; at the end of this ridge there appears to be a minute muscle scar. Another pair of shorter ridges outside of these, mark the position of the main lateral muscles.

*Sculpture.*—This consists of lamellose concentric ridges; toward the front margin of the valve there are about 8 in the space of a millimetre; the ridges are more closely set toward the sides and at the mid length of the valve; they anastomose more or less, and sometimes two or three run into another ridge, and are abruptly cut off.

*Size.*—Length of ventral 9 mm.; width 8 mm.; depth about 1½ mm. The dorsal is of the same depth, and is 1 mm. shorter.

*Horizon and locality.*—Sandstone and grit layers of Assise E 1 *b*, and in the shales of E 1 *c* at Dugald brook, Escasonie, N.S.

This species differs from *O. æquiputeis* in the weakness of the anterior scars of the central group, in the sharper sculpture and the strong prolonged lateral septa somewhat curved at the anterior end. From *O. discus* in the advanced position of the middle one of the three minor scars of central group and in the marked lateral septa, as well as the projecting umbo of the ventral valve. Contrasted with other species.

This species departs from typical Obolus in the projecting umbo, strong lateral septa and advanced position of the whole central group of muscle scars in the dorsal valves.

The following are dimensions of the valves in this species:

VALVES of Obolus triparilis from Assise E. 1 *b*,

| — | Number. | Length. | Width. | Depth. | Callus' length. | Resting stages of growth. | | Hinge, height. | Trunks, apart. |
|---|---|---|---|---|---|---|---|---|---|
| | | mm. | mm. | mm. | mm. | mm. | | mm. | mm. |
| Ventrals. | 1. | 8½ | 7 | 1 | ..... | 4½ | .... | .... | ..... |
| | 2. | 8½ | 7 | 1 | ..... | ..... | 7 | 1½ | .... |
| | | 17 | 14 | 2 | ..... | 4½ | 7 | 1½ | ..... |
| | Average | 8·5 | 7·0 | 1·0 | ..... | 4·5 | 7·0 | 1·5 | .... |
| Dorsals. | 1. | 8 | 8 | 1 | 6½ | ..... | 7 | 1 | 5 |
| | 2. | 9 | 10 | 1 | 5† | 5½ | 7 | 1 | 5 |
| | 3. | 7 | 8 | 1 | 5 | ..... | 6½ | 1 | 6 |
| | | 24 | 26 | 3 | 16½ | 5½ | 20½ | 3 | 16 |
| | Average | 8 | 8·6 | 1·0 | 5·5 | 5·5 | 6·8 | 1·0 | 5·3 |

Dimensions &c. of this species.

OBOLUS DISCUS, n.sp. Pl. VIII, figs 3 *a–d.*

is (E.) bed.

Evenly lenticular with the beak of the ventral slightly projecting. Length and breadth about equal.

Ventral valve rather flat, with an appressed umbo, scarcely elevated above the cardinal line, and but slightly projecting beyond the general circular contour of the valves. *Interior* not known.

The dorsal valve is evenly sloped toward the margins, which are somewhat flattened. A median sulcus appears in the back of the valve, near the hinge, and becomes wide and shallow towards the front; it extends two-thirds of the length of the valve. *Interior.*—The cardinal area is about one-seventh of the length of the valve, and has a wide pseudo-deltidium, transversely striated; this area is twice as wide at the margin of the visceral cavity as it is at the apex of the shell; the cardinal borders also are wide and are traversed by striæ that turn outward toward the lateral margin of the valve. Lengthwise along the centre of the valve is a raised callus that carries the central muscles; it is marked by a median and two lateral furrows, that extend about half of the length of the valve; at the front of the callus are the central group of scars (arranged in quincunx?) of which the two posterior are much larger than the others. The two anterior scars are connected with the two posterior by a faint thread-like ridge. The small central scar is about midway between the four.

*Sculpture.*—This consists of irregular, anastomosing, beaded ridges. Over some parts of the valves these markings are hardly distinguishable, and the surface appears granulated.

*Size.*—The largest ventral observed was 10 mm. long, and the largest dorsal 9 mm.; the width is about 9 mm., and the depth 1½ mm.

*Horizon and locality.*—Sandy layers in the shale of Assise E 1*e* Dugald brook, Escasonie, N.S. Not rare.

This differs from the next in its somewhat smaller size and more exact lenticular form of the dorsal valve; in the less prominent umbo of ventral, as well as the more irregular sculpture and the flattening of dorsal. The umbo of the dorsal seems to have been shortened.

The material for this species is scanty, and the following are dimensions &c. of the valves examined:—

VALVES of Obolus discus from Assise E. 1 *e*.

| — | Number. | Length. | Width. | Depth. | Callus' length. | Resting stages of growth. | Hinge's height. | Trunks, apart. |
|---|---|---|---|---|---|---|---|---|
| | | mm. | mm. | mm. | mm. | mm. | mm. | mm. |
| Ventral ..... | 1..... ..... | 10 | 10 | 1 | 5½? | 6½ 8 | 1½ | ..... |
| Dorsals..... | 1..... ..... | 9 | 9 | 1 | .... | 4½ 6½ | ½? | 6? |
| | 2... ..... | 9? | 9? | 1 | 6 | 6? | 1 | ..... |
| | 3..... | 7½ | 7 | ½ | 4½ | 3 5½ | ½? | ..... |
| | | 25½ | 25 | 2½ | 10½ | 7½ 18 | 2? | 6? |
| | Average.. . ..... | 8·5 | 8·3 | 0·8 | 5·2 | 3·7 6·2 | ·7? | ·6? |

Dimensions &c. of the valves.

OBOLUS ÆQUIPUTEIS, n. sp. Pl. VIII, figs. *a*—*e*.

Valves corneous equally lenticular, nearly orbicular in outline; umbones depressed. Obolus (E.) æquiputeis described.

Ventral valve with a short, low beak, having a narrow conical pedicle groove. Cardinal area broad. *Interior.* Opposite the pedicle groove is a small shallow pit, perhaps marking the point of attachment of the pedicle muscle. The lozenge heart-shaped area, or callus in front, is bordered by a strong furrow, outside of which, on each side in front, is the triangular imprint of the central group of muscles, In front of the middle of the valve, near the axial line are two minute pits, extending back from these across the heart-shaped area is a faint slender median ridge. Two strongly marked ridges, diverging from the umbonal region, separate the lateral group of muscles from the depression of the visceral cavity; these muscle scars extend forward on each side of the valve from the cardinal region as far as the centre of the heart-shaped area. In front of the ridges above named, are the grooves of the vascular trunks, which sweep around towards the front of the valve parallel to its margin.

The dorsal valve has a nearly orbicular outline, and a rather prominent, broad umbonal region. *Interior.* This shows a broad and long cardinal area. At the back of the valve, close to the hinge on each side of the umbonal region, are small scars apparently due to the posterior adductor. From the hinge on each side of the median line, a sharp ridge runs forward

as far as the scars of the central muscles, which are in the posterior third of the valve, are oval in form, and are about as far apart as half of the width of the cardinal line. A short distance in advance of these scars, but in the anterior half of the valve are the prints of the two anterior laterals; these are round, unusually large and are as far apart as the central muscles. At about equal distance from these four muscle scars and at the centre of the valve is a small pit, with a still smaller one in front of it, whose function is unknown. A short mesian ridge extends forward from between the scars of the anterior "j" laterals to two diverging furrows in front of these; these run from the point of divergence half way to the margins of the valve. In front of the forks of these furrows is a shallow round area, which with the space between the forked groove, is raised on the inside of the valve. Two strong ridges more widely separated at the back than those of the ventral valve, and less divergent, spread from the umbo. Outside of these diverging ridges are the prints of the posterior laterals. Running forward from the ridges in a curve parallel to the margin of the valve, vascular grooves are faintly indicated, and still more indistinct are traces of the interior branches of these trunks.

*Sculpture.*—At the umbo the dorsal valve is granulated, but concentric striæ appear at one millimetre from the umbo, and farther out the surface of the valve is diversified with numerous concentric ridges, to which the roughened surface of the shell give a granulated crest. The ventral valve is similarly marked, but there are concentric growth furrows at intervals.

*Size.*—The ventral valve has a length of 12 mm. and a width of 11 mm. In the dorsal the length and width are each 11 mm.

*Horizon and locality.*—In the sandstones and sandy shales of Assise E. 2 (a?), at Youngs point, near George river station, N.S.

The approximated central muscles and large widespread scars of the anterior laterals of the dorsal valve in this species distinguish it from all other Oboli, and from this and the peculiar grouping of the central group of muscles, the trivial name is derived.

## PALÆOBOLUS, sub-genus.

enus
bolus—
known.

"Distinguished from Obolus proper by the close approximation of the vascular trunks, as shown by their impression on the ventral valve, and by the forward direction of its branches. The callus of the visceral cavity of this valve is correspondingly narrow (therefore the muscle scars are also approximated). Yet the valve is round as in Obolus." [Bull. Nat. Hist. Soc. N.B., Vo'. IV., p. 202.]

This sub-genus characterizes the Upper Etcheminian Fauna.

The following is the original description of the species as published in Bulletin XX. of the Natural History Society o New Brunswick.

PALÆOBOLUS BRETONENSIS. Pl. IX., figs. 2*a* to *h*.

Palæobolus Bretonensi described.

"Oblately orbicular. Valves evenly rounded from the centre, except that the borders are flattened at the sides and front. Both dorsal and ventral valves somewhat pointed at the umbo, which is depressed in both valves. *Interior of the ventral.*—This has a broad hinge area and a triangular pedicle groove. The visceral cavity has two pairs of diverging ridges, which mark the advance of the lateral muscles during the growth of the shell. Between the outer and the inner pair originate the vascular trunks, which in going forward throw off branches at an acute angle. *Interior of the dorsal valve.* This valve has a broad, transversely striated hinge area. The visceral cavity is traversed by two pairs of diverging ridges, more widely divergent than those of the ventral valve; there is also a strong median septum along the middle of the valve. The central group of muscle scars are about a fifth from the front of the valve.

"*Sculpture.*—The whole outer surface, except close to the umbo, is ornamented with sharp concentric ridges which occasionally anastomose; these ridges have fine, faintly marked, radiating striæ on their posterior slopes, and are obscurely crenulated along their crests.

"*Size.*—Length 15 mm., width 17 mm. Dorsal valve somewhat shorter than the ventral." [Bull. Nat. Hist. Soc. N.B., Vol. IV., p. 202,]

The following are further particulars regarding this species.

Further particulars of this species.

*Ventral interior.*—The two pairs of diverging ridges extend across the posterior third of the valve; of these the outer pair divide off the posterior lateral muscles, and the inner pair are directed toward the point of attachment of the anterior laterals, to which they sometimes extend as a border to the central callus; in front of the callus on each side is a depression, marking the place of the central group of muscle scars. The vascular trunks in this valve run forward with a weak curve nearly to the front of the valve; the space between the trunks is about equal to one third of the width of the valve; beside the outer branches of the vascular trunks referred to above, traces of internal branches are also found towards the front of the valve.

*Dorsal interior.*—Of the two pairs of diverging ridges that traverse the posterior third of the visceral cavity, the outer are longer than the inner;

the latter which extend forward about one-third of the length of the valve from the umbo, are sometimes nearly doubled in length, and extend along the side of the depression marking the place of the central scars. Between the central scars a distinct septum is found, which begins opposite where the two inner pairs of ridges, described above, usually terminate, though sometimes it may be traced as far back as the hinge area. Where this ridge fades out in front is a depression, marking the place of the anterior lateral muscles. The central group of muscle scars extends to about one-fifth from the front of the valve. The vascular trunks in this valve are as far apart as half of the width of the valve.

*Sculpture.*—The general aspect of the surface ornamentation is described in the earlier publication above cited, the following are further particulars. For the first two millimetres from the umbo the ridges are very minute, or are absent; then outside of this they become visible with a strong lens; at from four to six millimetres from the umbo there are about eight ridges in the space of a millimetre, and for the rest of the shell about six to five, and finally four; near the front of the valve the ridges are lower, fainter and more closely set. The interior surface of the valves in this species, often exhibit more or less irregular rows of small pits; the rows are in general concentric to the umbo, and give the interior a rough appearance; these rows are often found at the resting stages in the growth of the shell, but other pits are miscellaneously distributed.

*Size* as given above 15 x 17 mm.; depth of two valves about 4 mm.

*Horizon and locality.*—In assise E. 3*d* of the Upper Etcheminian at Dugald brook, Escasonie; also at Gregwa brook, Escasonie, N. S.

Except the following species, *O. lens*, the Obolus nearest this age is *O (?) major*, of the Upper Etcheminian in New Brunswick: that species, however, is large, and does not have the concentric ridges, on the only example of it which is known. None of the European Oboli have the sharp ridges which mark the surface of this species, and they all belong higher in the geological scale. *Obolus (Michwitzia) monilifera*, Linrs., has a flattened dorsal valve, and thus differs from this species, it is also distinguished by its beaded surface.

This is the most noticeable brachiopod of the Upper Etcheminian fauna, both for size and for the strong ornamentation of the valves. Like *Lingulepis Gregwa* of the Lower Etcheminian fauna it seems to have preferred a muddy bottom, as it is found to abound in the beds of Assise *d*, which is more argillaceous than the assises above and below.

**The varying forms of the valves in the following table (and for other species in other tables of this article) are largely due to the distortion of the beds in which the fossils are preserved. This variation is corrected by the average.**

VALVES of Obolus Bretonensis from Assise E 3 *d.* (one from E. 3, *a.*)

| | Number. | Length. | Width. | Depth. | Callus' length. | Resting Stages. | Hinge's height. | Trunks, apart. | |
|---|---|---|---|---|---|---|---|---|---|
| | | mm | mm | mm | mm | | mm | mm | |
| Ventrals. | 1 | 17 | 14 | 2 | 8 | ..... 12 15 | .... | ... | Exterior, narrowed. |
| | 2 | 14 | 15 | 1 | 7 | 10 ..... | 1½ | 5½ | Interior, broadened. |
| | 3 | 14 | 12 | 1½ | 8 | ..... | 1½ | 3½? | " narrowed. |
| | 4 | 13+ | 16 | 1½ | .... | 8 ..... | .... | .... | Exterior, narrowed. |
| | 5 | 13 | 12 | 1 | 7? | 9 11 ..... | 1½ | 4 | Interior. |
| | 6 | 12? | 12 | 1 | ... | 9½ 10½ ..... | .... | .... | Exterior. |
| | 7 | 13 | 11 | 1½ | 7 | 9½ 10½ ..... | 1½ | 4 | Interior, narrowed. |
| | 8 | 10½ | 10 | 1 | .... | ..... | .... | 4 | " mouth of |
| | 9 | 12 | 10 | 1 | .... | ..... | 1 | .... | Exterior, narrowed— Assise E 3 *a.* |
| | | 119 | 112 | 11½ | 37 | 46 32 12 15 | 6¾ | 21 | |
| | Average.. | 13·2 | 12·4 | 1·3 | 7·4 | 9·2,10·6,12·0,15·0 | 1·3 | 4·2 | |
| Dorsals. | 1 | 13 | 15 | 1 | .. | 10 11 ..... | ... | .... | Exterior, broadened. |
| | 2 | 17 | 15 | 1 | .... | ... ... 13 15½ | .... | .... | " narrowed. |
| | 3 | 13 | 13 | 1 | ... | 9 10½ ..... | .... | .... | " oblique. |
| | 4 | 14 | 14 | 1 | 9½ | 10 12 ..... | 1 | 7½ | Interior " |
| | 5 | 14 | 14 | 1 | ... | 10 11½ ..... | 1 | ... | " mould of |
| | 6 | 14 | 14 | 1½ | 10+ | ..... .. | 1 | 7 | " " |
| | 7 | 15 | 14 | 1½ | 11 | ....11½ 13 .... | .... | .... | Exterior, exfoliated. |
| | 8 | 14 | 13 | 1½ | 9 | 9½ 11½ 13 .... | .... | 6? | " " |
| | | 114 | 112 | 9½ | 40 | 48½ 68 39 15½ | 3 | 20½ | |
| | Average | 14·2 | 14·0 | 1·2 | 10·0 | 9·7,11·3,13·0,15·5 | 1·0 | 6·8 | |

Dimensions &c. of the valves.

OBOLUS LENS, n. sp. Pl. X., Figs. *a* to *f*.

Shell rather thin and fragile, lenticular, nearly orbicular, with the beak of the ventral slightly projecting.

Ventral valve with a depressed beak, slightly sloping sides, and usually a depressed line, running along the mesian area. *Interior*, with a cardinal area about one-eight of the length of the valve. Within is a visceral callus, extending a little beyond the middle of the valve, and about twice as long as wide; at the front is the scar of the central muscles; on the callus, two-thirds from the beak, is a shallow lance oval depression. In front of the callus, but not always present, is a mesian ridge, bordered by shallow grooves. Scars of the lateral muscles are visible at the sides of the valve near the hinge line, outside of a long vascular ridge.

The dorsal valve shows wide, flattened areas at the posterior lateral slopes, and a narrow, widening, depressed band along the median line; or the centre is scarcely depressed, and there are two flattened ridges on the valve diverging from the umbo, and about as far apart at the front as one quarter of the length of the valve. Elsewhere the slopes of the valve are regular. *Interior.*—This is imperfectly known. The visceral callus extends beyond the middle of the valve, as is shown by the radiating septa that cross the visceral cavity; two of these ridges extend nearly to the front of the valve.

*Sculpture.*—This consists of fine concentric ridges that sometimes run together; there are about eight of these ridges in the space of a millimetre, and they are nearly regularly spaced except near the umbo; there are about twice as many of these ridges to the millimetre as in *O. Bretonensis.*

*Size.*—The ventral valve is about 14 mm. long, 12 mm. wide, and $1\frac{1}{2}$ mm. deep. The dorsal is about 1 mm. shorter than the ventral.

*Horizon and locality.*—In assises E. 3 *b* and E. 3 *e*, (especially the latter) of the Upper Etcheminian, Dugald brook, Escasonie, N.S.

This species is provisionally placed with the sub-genus Palæobolus, though the vascular trunks are not so close together as in that species (neither are they so wide apart as in the Obolus of Eichwald (Michwitz). Though proportionately a narrower shell than the preceding, this species is evidently congeneric with it, and appears to replace it in the more sandy beds of this zone. It can be distinguished from *O. Bretonensis* by the closeness of the concentric ridges on the surface of the valves. The crests of these ridges are not beaded as in *Obolus [illegible]*, Linrs. of the Swedish Cambrian.

The following table shows the size and main features of a number of valves.

## Valves of Obolus lens from Assise E. 3*e*.

| | Number. | Length. | Width. | Depth. | Callus' length. | Resting stages of growth. | | | Hinges' height. | Trunks, apart. | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | mm | mm | mm | mm | | | | mm | mm | |
| Ventrals. | 1 | 8 | 6+ | 1 | 5 | .... | ... | .... | 1½ | 4 | Interior, mould of |
| | 2 | 7½ | 6½ | 1 | .... | ... | .... | .... | .... | .... | Exterior. |
| | 3 | 7 | 6 | .... | .... | 4½ | .... | .... | .... | .... | " |
| | 4 | 7+ | 9 | 1 | 7? | .... | .... | .... | .... | .... | |
| | 5 | 11 | 11 | 1½ | .... | 5½ | 8 | 9½ | ... | .... | Both valves. |
| | 6 | 9½ | 8 | 1 | 6½ | 6½ | .... | ... | 1½ | 4 | Interior, mould of (on a slab). |
| | | 50 | 47 | 5½ | 18½ | 16½ | 8 | 9½ | 3 | 8 | |
| Average. | | 8·3 | 7·8 | 1·1 | 6·2 | 5·5 | 8· | 9·5 | 1·5 | 4. | |
| Dorsals. | 1 | | | | | | | | | | |
| | 2 | 10 | 11 | 1 | 6½ | 6½ | 8 | ... | 1½ | 5½ | Interior, mould of |
| | | 11 | 11? | 1? | 7? | .... | .... | .... | .... | 6? | Interior, exfoliated. |
| | 3 | 10? | 10 | 1 | 6? | .... | .. . | .... | 1¾ | 6 | |
| | 4 | 9? | 9 | 1 | 7 | .... | ... | ... | 1½ | 6 | Interior. |
| | 5 | 11 | 11 | 1½ | ... | .... | 7 | 9 | .... | .... | Both valves. |
| | | 51 | 52 | 5½ | 26½ | 6½ | 15 | 9 | 4¼ | 23½ | |
| Average. | | 10·2 | 10·4 | 11· | 6·6 | 6·5 | 7·5 | 9. | 1·4 | 5·9 | |

Dimensions &c. of the valves.

## Valves of Obolus lens from Assise E. 3*b*.

| | Number. | Length. | Width. | Depth. | Callus' length. | Resting stages of growth. | | Hinges' height. | Trunks, apart. | The dimensions are in millimetres. |
|---|---|---|---|---|---|---|---|---|---|---|
| Ventrals. | 1 | 11 | 10? | 1 | 6? | ..... | | 2 | 6 | Interior, exfoliated. |
| | 2 | 10 | 8+ | 1 | .... | .... | ..... | .... | .... | Exterior. |
| | | 21 | 18 | 2 | 6? | ..... | | 2 | 6 | |
| | | 10·5 | 9 | 1· | 6? | ..... | | 2· | 6· | Average. |
| Dorsals. | 1 | 10 | 8 | 1 | .... | 6 | 8 | 1¼ | .... | Exterior, exfoliated. |
| | 2 | 10 | 9 | 1 | .... | 7 | 9 | 1½ | .... | Interior, mould of, widened. |
| | | 20 | 17 | 2 | .... | 13 | 17 | 2¾ | .... | |
| | | 10· | 8·5 | 1· | .... | 6·5 | 8·5 | 1·4 | .... | Average. |

Dimensions of valves from assise E 3*b*.

Elsewhere we have noted the enlargement of the species of a genus in passing upward from one fauna to another, as, for instance, Acrotreta. A similar enlargement in size may be noted in Obolus.

| | Length. |
|---|---|
| Obolus torrentis, Coldbrook terrane..... ..... | 7 to 8 mm. |
| O.—— triparilis, Lower Etcheminian..... | 8 to 9 " |
| O.—— discus, Lower Etcheminian..... | 10 " |
| O.—— æquiputeis, Lower Etcheminian..... | 11 to 12 " |
| O.—— lens, Upper Etcheminian..... | 11 to 14 " |
| O.—— Bretonensis, Upper Etcheminian..... | 14 to 17 " |

Var. LONGUS, n. var. Pl. VII., Figs. 4*a* and *b*.

(P.) igus ed.

This at first sight appears quite distinct from *Obolus lens*, but has many points in common. It has the form of an oval Lingulella, and the position of the muscle sears of the ventral valve is like that of *Lingulella ovalis;* nevertheless the peculiar sharp, deep and long mesian furrow on back of the dorsal valve, and the ornamentation of the surface of the valves is so like that of *Obulus lens*, that we have concluded to place it as a variety of that species.

The general form is lance-oval and the width two-thirds of the length. Except in having shorter lateral vascular ridges, and in the difference of proportion due to difference of form, this species does not vary much from the type. It has the same mesian ridge in the ventral and a similar depressed longitudinal band on the dorsal. It has the shallow grooves along the mesian ridge of the ventral valve that is apparent in some examples of *Leptobolus collicia*. Its thin shell, weak cardinal area, flattened mesian band on the dorsal, and straightened lateral margins are Leptobolian characters; but it has distinct and rather coarse concentric ridges on its surface, while in Leptobolus this sculpture is fine and close. Michwitz appears to have met with similar forms that he had difficulty in placing as varieties of *Obolus (Schmidtia) obtusus*. They are of the Dictyonema Zone*

*Sculpture.*—This, consisting of close set concentric ridges, does not differ from that of *Obolus lens*, except in being finer and closer.

*Size.*—Length of ventral, 16 mm.; width, 10 mm.; depth, about 1½ mm. The dorsal is about 1 mm. shorter than the ventral.

*Horizon and locality.*—Occurs infrequently in assise E 3 c at Dugald brook, Escasonie, N.S.

The following are dimensions of valves of this form:

*Uber die Brachiopodengattung Obolus, Eichwald, Mem. Acad. Imp. des Sci. St. Petersb. Ser. viii., vol. iv., No. 2, Taf. ii., figs. 23-26 and 29-35.

VALVES of Obolus lens—longus from E. 3*e*.

| — | Number. | Length. | Width. | Depth. | Callus' length. | Resting stages of growth. | Hinges' height. | Trunks, apart. | The dimensions are in millimetres. |
|---|---|---|---|---|---|---|---|---|---|
| Ventrals. | 1 | 14 | 8 | 1 | .... | 7½ 11 | .... | 6 | Exterior, narrowed (on a slab) |
| | 2 | 16 | 10 | 1 | 9 | 10 13 | 1½ | ... | Interior, mould of |
| | 3 | 11 | 8 | 1 | 7 | 7 8½ | 1½ | .... | Exterior exfoliated |
| | | 41 | 26 | 3 | 16 | 14¼ 29½ 13 | 3 | 6 | |
| | | 13·7 | 8 7 | 1 | 8 | 7·2, 9·8, 13 | 1½ | 6 | Average. |
| Dorsals. | 1 | 10 | 8 | 1 | .... | 7 | .... | 6? | Interior exfoliated |
| | 2 | 9½ | 7 | 1 | .... | ... ..... | .... | .... | Exterior |
| | | 19½ | 15 | 2 | ... | 7 | .... | 6? | |
| | | 9·7 | 7·5 | 1 | .... | 7 | .... | 6? | Average. |

Dimensions &c. of the valves.

**The following is a synopsis of the occurrence of Obolus in the Etcheminian strata of Cape Breton, and in the Coldbrook terrane of the same island.**

DISTRIBUTION of Obolus in the Coldbrook and Etcheminian terranes in Cape Breton, N.S.

| — | Coldbrook. | ETCHEMINIAN. I | | | | | II | | | III | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *a* | *b* | *c* | *d* | *e* | *a* | *b* | *c* | *a* | *b* | *c* | *d* | *e* | *f* |
| Obolus torrentis | + | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| O.— (Eoobolus) triparilis | .... | + | + | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| O.— (————) æquiputeis | .... | .. | .. | .. | .. | + | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| O.— (————) discus | .... | .. | .. | .. | .. | .. | + | .. | .. | .. | .. | .. | .. | .. | .. |
| O.— (Palæobolus) Bretonensis | .... | .. | .. | .. | .. | .. | .. | .. | .. | + | .. | .. | + | .. | .. |
| O.— (————) lens | .... | .. | .. | .. | .. | .. | .. | .. | .. | .. | + | .. | .. | + | . |
| O.— (————) lens-longus | .... | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | + | .. |

Distribution of Obolus in the Basal Cambrian.

It will be seen that the Lower and Upper Etcheminian faunas are each characterized by a special subgenus of Obolus, one having a peculiar crowded arrangement of the central group of muscles of the dorsal valve, the other having the vascular trunks unusually approximated in the ventral valve.

## BILLINGSELLA, Hall & Clark.

### Billingsella retroflexa, Pl. X., figs 2*a*—*e*.

This was described as a variety of *Clitambonites plana*, Pander. But it has been found to belong to a much lower horizon than that species, and to be, by its internal characters, a Billingsella.

The ventral valve is flat, except toward the umbo, which is elevated, and for a short distance the shell has a convex slope on the back. *Interior.*—The mould of an example from the sandy shale of Young point shows clearly that this is not an Orthisina. The print of the adductors extends forward a little more than a third of the length of the valve, and is surrounded by a low ridge, connecting with the margin of the deltidium; a slight emargination at the side of the imprint limits the posterior adductor muscles. The print of the diductors extends far in advance of that of the adductors—more than half as far again as these. A lateral septum divides the diductors, and the posterior adductor is bounded by an accessory lateral septum. In front of the print of the adductors is a lanceolate depressed area, bordered by the minor pair of trunks of the vascular system; the outer pair of trunks turn outward around the print of the diductors, going toward the cardinal angle. The course of the branches of the vascular trunks is straight; they are numerous, but seldom fork; their impression is faint beyond the outer resting stage in the growth of the shell.

The dorsal valve is decidedly tumid in the middle portion, but curves down quickly to the hinge line, where there is a low area. *Interior.*—A mould of the dorsal shows that there was a median septum running from the umbo nearly two-thirds of the length of the shell; and on each side of the ridge appear three radiating vascular furrows. At the hinge line are the moulds of two short lateral plates, and at the centre of this line, on the mould, a group of three pits due to the crura and the cardinal process; the latter is larger than the other two.

*Sculpture.*—The material collected last summer has thrown considerable light on the sculpturing of the valves, which is so different on the two valves as to lead at first to the supposition that there are two species, with difference in the coarseness of the ornamentation—one with ribs on the

surface about as numerous as those described by Billings for *O. festinata*, the other with much closer and finer ribs like *O. orientalis* Whitfield. But on sorting the valves into ventrals and dorsals it was found that the valves with narrow ribs were ventrals, while those with wide ribs were dorsals. It might be supposed that this peculiarity would prevent the valves from fitting close together at the margins, but such a difficulty could have been obviated by a special smoothing of the edges of the valves.

The diversity in the width of the ribbing is most marked in the middle stages of growth; in both the larval and senile stages the valves were smoother. The spaces between the ribs in the dorsal valve are wider than the ribs; they are flattened and traversed by two, sometimes three, low fine, slender, thread-like ridges, parallel to the main ridges; on the lateral slopes the spaces between the ribs have only one of these low threadlike ridges.

This species has in the ventral valve 5 ribs in the space of 3 mm. and the dorsal has four in the same space, counting the thread-like ridges as well as the ribs.

*Size*—Length of the ventral, 18 mm.; width, 20 mm.; depth at the umbo, about 4 mm. The dorsal is about 2 mm. shorter and has a depth of 4 mm. about the middle of the valve.

*Horizon and locality.*—The original examples were from a bed of gray sandstone at McFee's (Young point), near George river station, Cape Breton, where it occurs with *Lingulella Selwyni* and was collected by Messrs. Weston and Robert, of the Canadian Geological Survey. The species also occurs, but of smaller size, in the sandy shales that underlie this sandstone. The sandstone in places is quite calcareous, and becomes as coarse as a grit. The fossils are in the condition of casts that have weathered out in this, now porous rock. These beds are tentatively assigned to Assise E 2. *a.* of the succession in the gorge at Dugald brook. Geological ag and locality.

Billings described the dorsal valve of his species (*B. festinata*) as being nearly flat. Such a description does not apply to *B. retroflexa*, in which this valve has the usual convexity of an Orthid. But the ventral valve is nearly flat, except near the umbo, though it slopes down to the hinge line on each side, owing to the elevation of the umbo.

*B. orientalis* of Whitfield has close, narrow ribs in the ventral valve (the dorsal is not known) like *B. retroflexa*, and might be compared with laterally compressed examples of this species, but the print of the adductor muscles in that species is much larger than in this.

*B. transversa* Walcott is not unlike longitudinally compressed examples of this species (*B. retroflexa*), but the fine ribs between the coarse ones, Compared with other species.

figured for that species, while found on the dorsal valve of ours, do not occur in the ventrals, and it is the ventral of his species that Mr. Walcott figures; however, he describes the species as having very fine costæ, 8 in the space of 3 mm.; our species has 4 or 5 in the same space, but young shells may have 6.

*Form.*—The valves differ considerably in their proportions, but this appears to be due to distortion after they were buried; as now found, the valves range from those in which the length and width are equal, to others in which the width is a half more than the length. Taking an average of a number of valves as shown in the accompanying table, the width appears to be one-quarter greater than the length, but less than this in the ventral valves.

VALVES of Billingsella retroflexa from sandstone of E. 2 (*a* ?) at at McFee's (Young point.)

(The dimensions in this table are in millimetres.)

| VENTRAL VALVES. | | | | | | | DORSAL VALVES. | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| — | Number. | Length. | Width. | Resting stages of growth. | | | — | Number. | Length. | Width. |
| Mould of exterior..... | 1 | 18 | 20 | ..... | ..... | | Moulds of interior... | 1 | 13 | 18 |
| Interior..... | 2 | 17 | 20 | ..... | . .... | | | 2 | 15 | 22 |
| Mould of exterior..... | 3 | 12 | 14 | 5 | | | | | | |
| sions of Mould of interior..... | 4 | 16 | 21 | | 12 | 14 | | | | |
| ves in Mould of exterior..... | 5 | 15 | 19 | 5 | 10 | 14 | | | | |
| one. Mould of exterior..... | 6 | 14 | 20 | 5 | 8 | 10 | | | | |
| Mould of interior. ... | 7 | 15 | 23 | ..... | | | | | | |
| | | 107 | 137 | 15 | 30 | 38 | | | [illegible] | [illegible] |
| Average..... | | 15·3 | 9 6 | 5 | 10 | 13 | Average ... | | 14 | 20 |

The following are measurements of valves from the sandy shale below the sandstone bed at Young point.

**Valves of Billingsella retroflexa from sandy shale at Young point.**

(The dimensions in this table are in millimetres.)

| Ventrals. | | | | | | | Dorsals. | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| — | Number. | Length. | Width. | Resting stages of growth. | | | — | Number. | Length. | Width. | Resting stages of growth. | | |
| M'd. of interior. | 1 | 13½ | 14 | 4 | 8 | 11 | Mould interior.. | 1 | 11 | 14 | | 7 | 10 |
| " exterior. | 2 | 11 | 10 | 3½ | 7½ | 10 | " " | 2 | 12 | 16 | | 7½ | 9½ |
| Exterior..... | 3 | 12½ | 11½ | | 6 | 8 | " exterior.. | 3 | 11 | 14 | ..... | | |
| " ..... | 4 | 10½ | 10½ | 4 | 6 | 9 | " interior.. | 4 | 12 | 13 | | 8 | 11 |
| Mould exterior. | 5 | 10 | 14 | | | | " " | 5 | 11½ | 13 | | 8 | |
| Young " | 6 | 5½ | 6 | | | | " " | 6 | 11 | 16 | 3 | 7 | 9 |
| Mould of " | 7 | 11 | 16 | | | | " " | 7 | 11 | 12 | 3½ | 8 | 10 |
| | | | | | | | " exterior.. | 8 | 13 | 17 | | 6 | 9 |
| | | | | | | | " " | 9 | 10 | 17 | | 7 | |
| | | 74½ | 82 | 11½ | 27½ | 38 | | | 102½ | 132 | 6½ | 58½ | 58½ |
| Average..... | | 10·6 | 11·7 | 3·8, | 6·9, | 9·5 | | | 11·4 | 14·7 | 3·2, | 7·3, | 9·7 |

Dimensions of others from the sandy shale.

The greater proportionate width of the dorsal is due chiefly to its shorter umbo. The shells in these shales are proportionately narrower than those in the sandstone bed; they are also much smaller, but the difference does not seem to be specific.

Owing to the coarseness of the matrix both in the sandstone and the shales, the finer details of surface ornamentation are obscured.

## OSTRACODA.

### Ostracoda of the Basal Cambrian Rocks in Cape Breton.

Peculiarities of the Ostracoda of the Basal Cambrian

'Investigations of the Cambrian rocks in Cape Breton has brought to the writer's notice a number of new types of these small Entomostracans, and with the permission of the Director of the Canadian Geological Survey, these were communicated to the Natural History Society of Montreal. (See Can. Rec. Sci., Vol. VIII page 437.)

The species all come from the Etcheminian sandstones and shales, and from a body of shales included in the volcanic rocks which underlie them. This part of the Cambrian appears to contain three faunas, one in the shales of the volcanic rocks, and two in the Etcheminian sediments.

Only two species of Ostracoda have been found in the shales of the volcanic rocks, so that the bulk of the fauna is Etcheminian. The distribution of the forms throughout this series of beds will be readily seen by the accompanying table. The three larger divisions of the Etcheminian shown in the table are lithological, and the Lower Etcheminian Fauna is confined to the two lower divisions; the Upper Fauna is in III of the upper division. The letters beneath these divisional spaces indicate the successive assises in which fossils have been found. No Ostracoda of the Protolenus Zone have been recognized in these beds, and so it is supposed they are older than that fauna.

List of Ostracoda of the Coldbrook and Etcheminian terranes in Cape Breton with the horizons at which they are found.

| | | Names of species, mutations and varieties. | Coldbrook. | Etcheminian | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | I. | | | | | II. | | | III. | | | | |
| | | | | *a* | *b* | *c* | *d* | *e* | *a* | *b* | *c* | *a* | *b* | *c* | *d* | *e* | *f* |
| | | Leperditia (?) rugosa | | | | | | | | | | | | | | | x |
| | Rutelliform. | Bradorona perspicator | | | | | x | | | | | | | | | | |
| | | " " mut. maxima | | | | x | | | | | | | | | | | |
| | | " " " magna | | | | | | | x | | | | | | | | |
| | | " " " major | | | | | | | | | | | | | | | x |
| | | " spectator | | | | x | x | | | | | | | | | | |
| | | " " mut. acuta | | | x | | x | | | | | | | | | | |
| | | " " " spinosa | | | | | | x | | | | | | | | | |
| | | " " " æquata | | | | | | | | | | | | | x | | |
| | Oblique. | " observator | | | | | x | | | | | | | | | | |
| | | " " var. benepuncta | | | | | x | | | | | | | | | | |
| | | " " mut. lævis | | | x | | | | | | x | | | | | | |
| | | " " " ligata | | | | | | | | | | | | | | x | |
| | Small. | Bradoria scrutator | | | | | | | | | | | | | | x | |
| | | " vigilans | | | | | | | | | | | | | | x | |
| | | " " mut. obesa, &c. | | | x | x | x | | | | | | | | | | |
| | | " rugulosa | | | | | | | | | | | | | | x | |
| | | " (?) ornata | | | | x | | | | | | | | | | | |
| | | Escasona rutellum | | | | | | | | | | | | | | | x |
| | | " (?) vetus | | | | | x | | | | | | | | | | |
| | | " (??) ingens | x | | | | | | | | | | | | | | |
| | | Indiana ovalis | | | | | | x | | | | | | | | x | |
| | | " " mut. prima | x | | | | | | | | | | | | | | |
| | | " lippa | | | | | | | | | | | | | | | x |
| | | Schmidtella (?) pervetus | | | | | | | | | | | | | | x | |
| | | " " mut. concinna | | | | | x | | | | | | | | | | |
| | | " (?) acuta | | | | | | | | | | | | | | x | x |
| | | | 2 | | 3 | 4 | 8 | 2 | | 1 | 1 | | | | 1 | 7 | 5 |

bution Ostra- n the Cam- rocks.

The Ostracoda found in those deposits afford a means of discriminating the layers, second only to the Brachiopoda. They are not nearly so numerous as the latter, or they would be even more valuable in this respect, as they show considerable liability to variation. The forms of Bradorana are specially abundant in the Lower Etcheminian strata, while Bradoria and Schmidtella (?) are more common in the Upper. From their small size these Ostracoda are easily overlooked, but their thick and strong shells have resisted destructive agencies, and give examples that have not suffered so much from distortion and pressure as some of the Brachiopods. They possess some features of form and structure which are peculiar. One notable feature is the position of the main muscle scar. Mr. E. O. Ulrich, who has given much attention to the study of the Ordovician and Silurian Ostracoda seems to assume that the place for the muscle is near the centre of the valve. At least he speaks of this as the position of this mark in Leperditia*; it is from the hinge to this point that the sulcus or transverse groove extends in this genus. And if there is any meaning in this connection in the central depression of the valve a similar position for the muscle scar may be inferred for Primitia, Primitiella, Isochilina, Kirkbya, Entomis and other genera. Peculiarities of structure in the Ostracoda of the Basal Cambrian.

But in the Etcheminian species of Ostracoda and in many of those of the Protolenus Fauna of the St. John Group, we have not been able to find any in which the muscle scar is so placed. On the contrary many examples occur in which the scar holds an anterior position near the hinge line. This peculiarity would have given greater mobility to the valves, and it is a fact that while in many cases we find the valves spread somewhat apart, there are others in which they are spread out flat and yet retain their normal position of contact at the hinge line.

If there is any meaning in these furrows that extend from the hinge as indicating muscular attachment there is a suggestion of a posterior muscle, towards the posterior end of the cardinal line in the depression that exists there in Beyrichona and Hipponicharion, and is faintly shown in Escasona. But of such posterior muscle we have no sure evidence. Of the anterior adductor muscle, however, there are plain indications on the interior of many valves.

It is clear that Ostracods having such a radical difference of structure from those of a later time, must have had different habits of life, and among other peculiarities noted is that they usually occur solitary. Peculiarities of habitat.

*Lower Silurian Ostracoda of Minnesota, p. 633.

Seldom do we find any aggregations of individuals, and never the swarms on a single layer of rock that may be found in occurrences of the later Ostracods; hence they appear not to have possessed in any marked degree the gregarious habit of these later genera.

Another peculiarity of the Etcheminian and Protolenian forms, as distinguished from the prevalent Ostracoda of Ordovician and Silurian Time, is the unusual convexity of the front moiety of the valve as compared with the other. This for some time led the author to be uncertain as to which was the anterior end of the valve in the genus Beyrichona. He, however, now has no longer any doubt, as the related genus Bradoria, with its prominent ocular tubercle sets this matter at rest, and shows that the thick end of the valves is the anterior one.

Another common feature is the prevalence of species which are as wide, or wider than long. This peculiarity is connected with a long hinge line and with more or less abrupt cardinal curves of the margin, before these merge into the true anterior and posterior margins of the valves (see Plate I. figs. 1 to 6, *a* & *b*). When the angle at the lower end of these cardinal curves is acute, a tubercle is sometimes developed, in addition to that which marks the anterior and often the posterior end of the hinge line (Pl. I. fig. 13, *a* & *c*).

These laterally expanded valves are in a number of species somewhat pointed at the lower margin, and in most the ventral margin is more or less angulated (Pl. XII. figs. 2, 3 and 6). It thus admits of division into two portions which may be designated the anterior and posterior curves (*c* & *d*). according to whether the part of the margin indicated is in front or behind the ventral angulation. Sometimes the anterior curve of the margin will be stronger as in Beyrichona (Fig. 3) (and Escasona? Fig. 6), sometimes the posterior curve, as in Indiana (Fig. 1) and Bradorona (Fig. 2), is the stronger. In Hipponicharion (Fig. 4) the two are about equal.

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Ostra-

The cardinal curves (Pl. XII. figs. 2 etc., *a* and *b*), extend from the hinge line along the margin until it becomes at right angles to the hinge, and they also vary greatly in direction and extent. Thus in Indiana (Fig. 1) the posterior one is long, the anterior shorter; in Bradorona (Fig. 2) they are approximatively of equal length; in Beyrichona (Fig. 3), sp. *palpilio*, the posterior one is almost obsolete, but in other species (*tinea*, *planata*, *etc.*,) of this genus, it is well shown, and with these the species of Escasona (Fig. 6) agree. In Bradoria (Fig. 5) both cardinal curves, and especially the posterior, are well shown. In Hipponicharion on the contrary these curves are almost obsolete.

The relation of the muscle scar to the ocular tubercle is also a means of discriminating the genera in these early forms of Ostracoda: thus in Bradorona (Fig. 2) and Bradoria (Fig. 5) it is diagonally behind and below the tubercle, but in Beyrichona it is below and somewhat in front of the tubercle. In Hipponicharion (Fig. 4) the muscle print presses in behind and below the tubercle. In Indiana (Fig. 1) the scar though not well recognized appears to be as in Bradorona (Fig. 2). In Escasona neither muscle scar nor tubercle have been certainly identified.

Radically different from the Leperditidæ.

Comparing this group of genera with those of the Ordovician and Silurian, we note some obvious differences from them. Perhaps the most notable is the way in which the visual and muscular organs are crowded at the front end of the hinge. This would exclude them from the great family of the Leperditidæ, Jones, in which the muscle scar is near the middle of the valve. The lateral expansion of the valves also is characteristic, and still more the way in which a number are pointed at the middle of the ventral margin.

We see no nearer relation in these species to the "zoe" group of giants described by Barrande, than to the Leperditidæ; these remind one more of the bivalve carapaces of Phyllopod crustaceans. The Canadian forms, though many are above the average size of the fossil Ostracoda, are far inferior in this respect to Aristozoe and its allies.

It seems to the writer that the position of the main adductor muscle scar separates these species from all described Ostracoda, and he would suggest for them the designation Bradoriidæ, taking as types the genera Beyrichona and Bradoria. Hipponicharion is widely divergent from the others and in its strongly ridged surface simulates Beyrichia and may for the present be placed in the family Beyrichidæ.

### Leperditia?? rugosa. Pl. XII, fig. 7*a* to *c*.

(Can. Rec. Sci., Montreal, Vol. VIII., p. 443. 1902.)

Leperditia?? rugosa described.

This species may prove to be of another genus when more numerous examples are found. The single example found does not seem to justify a final reference to any described genus.

Only the right valve is known and this is rather flat, and flattened toward the hinge and the posterior slope; its greatest convexity is in the middle and the lower third. The outline is broadly oval, with a hinge line half of the length of the valve. The anterior and posterior cardinal curves are long; the posterior marginal curve and the lower side of the valve are both somewhat straightened, and the anterior marginal curve strongly rounded.

There is an obscure ocular tubercule situated at the upper front angle of the valve; and an obscure, short and weak furrow behind it; about the middle of the cardinal line is a low, faintly marked tubercle. There is a trace of a marginal furrow along the posterior margin.

*Sculpture.*—Corrosion of the surface has obscured the usual markings, leaving a rough surface, which is crossed in several directions by broken ridges, without regularity; except toward the lower margin of the valve, where there are several sub-parallel to the margin.

*Size.*—This is the largest Ostracod obtained from the Etcheminian terrane—Length 6½ mm., width 5 mm., depth about 1¼ mm.

*Horizon and locality.*—Assise E. 3. f. Upper Etcheminian, at Gillis', Indian brook, Escasonie, N.S., scarce.

The flat form and wrinkled surface of this valve indicates a thin chitinous test. It may have distant affinities with *Isoxys*, Walcott, but is entirely different in form. It also approaches in outline *Aristozoe rotundata* Walcott,* but is of different relief.

## BRADORONA.

Bradorona, new subgenus.

The description of the genus Bradoria applies more particularly to the smaller elongate forms, described in the Bulletin of the Natural History Society of New Brunswick.† But beside these the Etcheminian beds contain a group of larger forms, with similar ocular tubercule and muscle scar, but broader and more triangular in form; most of them belong to the Lower Etcheminian Fauna but there are stragglers in the upper. With their more angulated form they have the front marginal curve straightened. These we propose to distinguish as a subgenus under the name Bradorona.

### BRADORONA PERSPICATOR. Pl. XII, fig 8*a*. to *d*.

(Can. Rec. Sci., Montreal, p. 444, 1902).

Bradorona perspicator described.

This is one of the largest Ostracods found in the Cape Breton Etcheminian rocks and, if the following mutations are properly referred to it, extends through them in varying forms and sizes.

In this typical form the hinge is more than three-fifths of the width of the valves. The posterior cardinal curve is long and straight, the margin bears a thread-like marginal fold on the left valve and there is a narrow

*Fauna of the Olenellus zone p. 627 pl. i. xxx fig. 3.

†Bull Nat. Hist. Soc. N. B. Vol. iv. p. 204 St. John 1899.

obscure furrow, within the margin along the anterior and posterior marginal curves. The hinge margin is thickened, and a tubercle marks the posterior end of the hinge line (of at least the right valve). The ocular tubercle is distinct in each valve, behind which is a shallow furrow extending a short distance below it. There is also a short, obscure ridge extending obliquely downward from the ocular tubercle toward the lower margin of the valve.

The greatest convexity of the valve is two-fifths below the hinge line, and the slope to the anterior margin is steep.

*Sculpture.* In all the forms of this species obtained, the sculpture has been obscured by corrosion, but remains of the cortex that have escaped this destructive change show a pitted surface. By a linear arrangement of the pits along the anterior and posterior slopes of the valves an appearance of parallel ridges has been produced.

*Size.* Length $4\frac{3}{4}$ mm. Width 4 mm. Depth of each valve $1\frac{1}{2}$ mm.

*Horizon and locality.* This is of the Lower Etcheminian Fauna, and occurs in Assise E. 1. d. at Dugald brook, Escasonie, N.S.—Frequent.

The following measurements exhibit some variations in size.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| A right valve, | length | $4\frac{1}{2}$ | mm., | width | $4\frac{1}{2}$ | mm., | depth | $1\frac{1}{2}$ | mm. |
| Another | " | " | 4 | " | " | $4\frac{3}{4}$ | " | " | $1\frac{1}{2}$ | " |
| A left | " | " | 4 | " | " | $4\frac{3}{4}$ | " | " | $1\frac{1}{2}$ | " |

Mutation MAXIMA. Pl. XII., figs. 9. *a*, *b*.

Can. Rec. Sci. Montreal, Vol. VIII., p. 445, 1902.

This is the largest form of the species observed; it is more rounded at the two ends and below, than the type, and is flatter, but is of the same general form. Mutation maxima described.

The hinge-line is two-thirds of the length of the valve. The posterior cardinal curve is angulated. There is an obscure furrow behind the ocular tubercle, extending half across the valve; a low ridge extends along the anterior margin, a little within it, and a fainter ridge along and near the posterior cardinal curve; a narrow marginal furrow is visible along the anterior marginal curve; an obscure row of tubercles extends along and near the anterior half of the hinge of line.

*Sculpture.* Surface pitted, the spaces between the punctures becoming anastomosing ridges near the margin, and presenting ridges on the posterior half of the valve, sub-parallel to the margin.

*Size.* Length 6 mm., width 5 mm., depth of a valve $1\frac{3}{4}$ mm.

*Horizon and locality.*—Assise E. 1 *c*, Lower Etcheminian, at Dugald brook; scarce.

### Mutation MAGNA, Pl. XII figs. 11 *a* and *b*.

Can. Rec. Sci., Montreal, 1902, Vol. VIII., p. 446.

Mutation magna described.

Valves rather tumid, hinge-line shorter than in the type, two-fifths of the length of the valve; ocular tubercle prominent, behind and around it is a shallow furrow; cardinal curves of the margin long. No marginal furrow is visible.

*Sculpture.* Surface pitted; there are obscure anastomosing ridges between the pits parallel to and near the margin; a narrow obscure band extends from ocular tubercle obliquely backward and downward.

*Size.* Length, 5 mm.; width, 4 mm.; depth of a valve 1½ mm.

*Horizon and locality.* Assise E. 2 *b*, Lower Etcheminian, at Dugald brook; scarce.

### Mutation MAJOR, Pl. XII., figs. 10 *a* and *b*.

Can. Rec. Sci. Montreal, 1902, Vol. VIII., p. 446.

Mutation major described.

Valves rather tumid, hinge-line about three-fifths of the length of the valve. Cardinal curves rounded; no marginal furrows seen. Ocular tubercle a little way from the hinge; a broad obscure furrow behind it. An obscure ridge runs from the posterior marginal curve to the anterior middle of the valve, and thence curves up to the lower end of the anterior cardinal curve.

*Size.* Length 5½ mm.; width 4½ mm.; depth of a valve 1½ mm.

*Horizon and locality.* Assise E. 3 f., Upper Etcheminian at Dugald brook; scarce.

### BRADORONA SPECTATOR. Pl. XII., figs. 12 *a* to *d*.

Can. Rec. Sci., Montreal, 1902, Vol. VIII., p. 447.

Bradorona spectator described.

This species is smaller than the preceding and has a more finely pitted surface. The length and breadth of the valves are about equal. Length of the hinge more than half that of the valve (?); the anterior and posterior cardinal curves are about equal in length; both anterior and posterior marginal curves are convex. The upper part of the valve is most protuberent as in Schmidtella. A sharp marginal furrow shows on some valves. The ocular tubercle is prominent; some examples show a short

thread-like ridge extending diagonally backward from the tubercle; this corresponds to a furrow on the inside of the valve.

*Size.* Length and breadth each 3½ mm.; depth of a valve 1 mm.

*Horizon and locality.* In the dark, brownish gray sandy shale of Assise E. 1 *d*, Lower Etcheminian, at Boundary brook, Escasonie, Rather common. Also in Assises E. 1 *b*. and E. 1. *d*. at Dugald brook; infrequent.

### Variety ACUTA.

Can. Rec. Sci., Montreal 1902, Vol. VIII., p. 447.

This is a large form, more pointed below than the type. Anterior marginal slope somewhat straightened. Ocular tubercle distinct. Variety acuta.

*Sculpture.* Surface minutely punctuate, and showing a strong striation near the hinge.

*Size.* Length and breadth each about 4 mm.; depth of a valve 1 mm.

*Horizon and locality.* Assise E. 1 b., Lower Etcheminian, at Dugald brook; infrequent.

A small example, supposed to be the young of this form is narrower, more acutely pointed below, and with straighter anterior and posterior marginal curve, was found in Assise E. 1 *d*. at Boundary brook.

### Mutation SPINOSA. Pl. XII., figs. 13 *a* and *b*.

Can. Rec. Sci., Montreal, 1902, Vol. VIII., p. 448.

Wide below the cardinal curves. Anterior marginal curve straightened. A sharp marginal furrow all around except at the hinge. Mutation spinosa.

The ocular tubercle is distinct and there are spines at the ends of the cardinal curves, except at the lower end of the posterior curve.

*Sculpture.* The surface is minutely punctuate; on the posterior slope of the valves and on a band descending backward from the ocular tubercle, the pits merge into interrupted striæ, divided by inosculating ridges.

*Size.* Length and breadth each about 4 mm.; depth of a valve 1¼ mm.

*Horizon and locality.* An entire carapace in the Assise E. 1 *e*., Lower Etcheminian, at Dugald Brook; scarce.

### Mutation ÆQUATA. Pl. XII., figs. 14 *a* and *b*.

Can. Rec. Sci., Montreal, 1902, Vol. VIII., p. 448.

Anterior and posterior sides nearly equal. The form is oval, and is wide below the cardinal curves, which are long. Anterior as well as posterior marginal curve regularly arched.

*Sculpture.* The surface has been corroded, but shows traces of a minute pitting.

*Size.* Length and breadth each $3\frac{3}{4}$ mm. ; depth of a valve 1 mm.

*Horizon and locality.* In Assise E, 3 *d*. Upper Etcheminian Fauna, at Dugald brook. Rare.

### Bradorona observator. Pl. XII., figs. 15 *a* to *c*.

Can. Rec. Sci., Montreal, 1902, Vol. VIII., p. 448.

A small species of the same general form as the preceding, but the anterior marginal curve is more oblique on the hinge line, the ventral angle being opposite to the posterior half of the cardinal line ; this (2 mm. long) is considerably more than half the length of the valve.

The anterior cardinal curve is angulated at each end ; the posterior is a third longer than the anterior. The anterior marginal curve is straightened and is considerably longer than the posterior, which is strongly arched outward. A narrow thread-like marginal fold is visible in some places. A thickened band within the margin, in some places, shows slight protuberences.

*Sculpture.* In most examples the surface is scabrous from corrosion, but some show traces of a minute pitting, and near the margins of the valve these pits form continuous rows, or furrows. The mould of the interior showing smooth surface having minute punctures. The muscle scar behind the ocular tubercle, is distinct on the mould of the interior of the valve.

*Size.* Length $3\frac{1}{2}$ mm ; width 3 mm ; depth of a valve 1 mm.

*Horizon and locality.* In Assise E. 1. *d*., Lower Etcheminian, at Boundary brook. Common.

The following are measurements of several valves from this locality :

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Left valve, length | $3\frac{1}{4}$ | mm., | width | $2\frac{1}{2}$ | mm., | depth | 1 | mm. |
| 2 " | " | " | $3\frac{1}{2}$ | " | " | 3 | " | " | 1 | " |
| " | " | " | $3\frac{1}{4}$ | " | " | $2\frac{3}{4}$ | " | " | $\frac{3}{4}$ | " |
| " | " | " | $3\frac{1}{4}$ | " | " | $2\frac{3}{4}$ | " | " | $\frac{3}{4}$ | " |
| Carapace | " | $3\frac{3}{4}$ | " | " | $2\frac{3}{4}$ | " | " | 2 | " |

Three forms which may be classed as varieties of this species are the following:

### Variety BENEPUNCTA. Pl. XII., fig. 16.

Can. Rec. Sci. Montreal, 1900, Vol. VIII., p. 449.

Variety benepuncta described.

Anterior cardinal curve longer than the posterior; anterior marginal curve straightened and the greatest width of the valve posterior to the middle. Hinge-line nearly half of the length of the valve ($2\frac{1}{2}$ mm). Ocular tubercle distinct; a shallow furrow behind and below it. A faint ridge extends forward from the posterior end of the hinge half way to the furrow below the ocular tubercle. Another example, more oval and more tumid, has an obscure row of tubercles arching outward and forward from the posterior cardinal angle to the anterior cardinal curve. A low ridge extends back from the ocular tubercle to the hinge.

*Sculpture.* The surface is corroded, but on the posterior slope of the valve are anastomosing ridges parallel to the margin.

*Size.* Length, $4\frac{1}{2}$ mm.; width, $3\frac{1}{2}$ mm.; depth of a valve, 1 mm. A carapace from this locality had length $4\frac{1}{4}$ mm; width, $3\frac{1}{4}$ mm; depth of the two valves, 3 mm.

*Horizon and locality.* Assise E. 1. *d.*, Lower Etcheminian, at Boundary brook. Scarce.

### Mutation LÆVIS.

Can. Rec. Sci. Montreal, 1902, Vol. VIII., p. 450.

Mutation lævis described.

Oval, cardinal curves long, the anterior one rounded. Hinge line more than half the length of the valve ($\frac{5}{8}$), a tubercle at the posterior end. Ocular tubercle off from the hinge-line and prominent; ocular furrow shallow. The right valve has a thread-like marginal fold; no fold on the posterior slope of the left valve.

*Sculpture.* Punctuation fine, showing anastomosing ridges near to and parallel to the posterior slope of the valve. An example from the higher horizon shows a thickened band near the margin along the posterior marginal slope, that bears obscure elongated tubercles. An example of the mould from the same horizon has three small pits behind the ocular tubercle, parallel to the hinge.

*Size.* Length, $4\frac{1}{4}$ mm; width, $3\frac{1}{4}$ mm; depth 1 mm.

*Horizon and locality.* Occurs in assises E. 1. *b*, and E 2 *c*, Lower Etcheminian, at Dugald brook.

The following are measurements of examples from the two horizons:

E. 1. *b*, carapace, length, 4 mm.; width, 3 mm.; depth, 2¼ mm.
" " " 3¼ " " 3 " " 1¼ "
E. 2*c*, right valve " 4¼ " " 3¼ " " 1 "

### Mutation LIGATA, Pl. XII., fig. 17.

Can. Rec. Sci. Montreal, 1902, p. 451.

Oval, cardinal curves long, anterior marginal curve straight, posterior ornamented with a row of small tubercles; a similar row extends direct from the lower end of the posterior cardinal curve toward the lower end of the valve, near which it curves forward. Ocular tubercle obscure, it appears to be represented by four small tubercles; but the furrow is well marked.

*Sculpture.* The punctation is rather coarse, and there are anastomosing ridges near the two ends of the valve, parallel to the margin.

*Size.* Length 4 mm.; width 3 mm.; depth of two valves, 2 mm.

*Horizon and locality.* Assise E. 3. *e*., Upper Etcheminian, at Dugald brook, Escasonie, N.S. Rare.

## BRADORIA*

Named for the Bras d'Or, a salt water lake occupying the interior of the island of Cape Breton.

"In the Protolenus Fauna are two species of Ostracoda which, for want of other known relationship, were referred to the genus Primitia. It would appear now that they are representatives of an ancient type of crustaceans which has species in the Etcheminian Fauna. Though having the general form of Primitia, Primitiella and Aparchites, they do not have the median pit, or sulcus of the first, the shallow median depression of the second, or the smooth valve of the third. Their most marked character is a prominence or tubercle at the front of the hing-line. From the smoothness of the summit of this tubercle, and its advantageous position for vision, it is supposed to be an ocular tubercle. Some of the species have, close behind this tubercle, a short vertical furrow; or the furrow may pass around the tubercle. In the five species referred here the marginal furrow is obscure, or in side-view along the lower margin, invisible.

The known species are of nearly the same size—about 3 to 4 mm. long and the surface of the valves is distinctly pitted, tuberculated or wrinkled.

*Nat. Hist. Soc. N. Brunswick, Bull. vol. iv., p. 204.

The following are the species which fall under this genus: *Primitia oculata* and *P. aurora* of the Protolenus Fauna and the following species":

BRADORIA SCRUTATOR. Pl. XIII., figs. 1 *a* to *c*.

*Bradoria scrutator*, n. sp. Nat. Hist. Soc. N.B. Bull. vol. iv., p. 204, pl. iv., figs. 1. *a* to *c*.

Can. Rec. Sci. Montreal, 1902, p. 452.

Bradoria scrutator, original description.

"Outline of the valves ovate, with a straight hinge-line. Hinge-line more than half the length of the valve, terminating in front at a short transverse furrow, situated immediately behind the tubercle. The hinge is bordered all along its course by a narrow sharp ridge, similar to a marginal ridge. The tubercle is nearly marginal, and is situated just in front of the hinge-line. In front of it the margin of the valve turns downward and is bordered by a narrow, obscure furrow, which extends around the ventral margin of the valve. There is a slight angulation of the outline of the valve at the middle of the anterior border, separating there the cardinal and anterior curves. The posterior margin rounds regularly upward behind to the hinge-line.

*Sculpture.* (1) The whole surface of the valve is covered with closely set, rather coarse, conspicuous pits that are finer toward the hinge where they have a linear arrangement." On the posterior half, toward the posterior margin, the tubercles between the pits have a tendency to coalesce, and thus produce obscure ridges whose course is directed toward the lower border of the valve.

*Size.* Length, 3 mm.; width, 2¼ mm.; depth, 1 mm.

*Horizon and locality.* Assise E. 3. *c*., Upper Etcheminian, at Dugald brook, Escasonie, N.S.

Additional characters.

Additional material shows much better the characters of this species. In this the valves have been of a more distinctly oval form than in those of *Bradorona observator*, the cardinal curves being rounded so that the straightening of the anterior marginal curve alone defines the length of the cardinal curve above it. The posterior cardinal curve is rounded to the hinge, and the lower edge of the valve is broadly rounded.

*Sculpture.* (2) The interior shows a large muscle scar near the hinge-line, behind the ocular tubercle; and also an unusually long straight groove, directed backward and downward, in front of the tubercle; a fainter, shorter groove directed toward the anterior margin lies in front of this. A thickened band of the shell substance, making a slight ridge

on the inner surface, extends from the posterior cardinal angle, around the ventral slope of the shell to the anterior marginal curve. The following are measurements of some valves :—

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Left valve, | length | 3mm. ; | width | $2\frac{1}{4}$ | mm. ; | depth | 1 | mm. |
| Right | " | " | $3\frac{1}{4}$ | " | " | $2\frac{1}{4}$ | " | " | 1 | " |
| " | " | " | 3 | " | " | $2\frac{1}{3}$ | " | " | $1\frac{1}{4}$ | " |
| Carapace | | " | $2\frac{3}{4}$ | " | " | 2 | " | " | 2 | " |

As compared with the species of the Protolenus zone—this species is a little larger than *B. oculata*, from which it is easily distinguished by the character of the surface ornamentation ; in the Etcheminian species the pits are coarser and closer together, and it thus has a rougher surface than the species above named. The sculpturing is more like that of *Isochilina ventricosa*, which, however, is a much larger species. *P. aurora* of the Protolenus zone is nearly of the same size, but it differs in the strong anterior furrow, and in its finely pitted surface.

BRADORIA VIGILANS. Pl. XIII., figs. 2 *a* to *c*.

*Bradoria vigilans*, n. sp. Nat. Hist. Soc. N. B. Bull, vol. iv., p. 205, pl. iv., figs. 2 *a* to *c*.

Can. Rec. Soc. Montreal, 1902, p. 454.

Outline of the valves ovate, somewhat pointed behind, moderately arched transversely, the valves somewhat ridged lengthwise. The right valve has a hinge-line about half of the length of the valve, which is flattened down at the hinge forming there a lance oval area. There is a prominent tubercle at the front of the hinge surrounded by a shallow groove. The margin is gradually rounded from the front, and projects somewhat at the posterior end, whence the posterior cardinal curve goes directly upward to the back of the hinge.

*Sculpture.* The surface is marked by close set granulations, that become finer toward the hinge-line and the ocular tubercle ; at the posterior quarter of the valves the granulation graduates into a series of subparallel anastomosing ridges.

*Size.* Length $3\frac{1}{2}$ mm. ; width $2\frac{1}{2}$ mm. ; depth $\frac{3}{4}$ mm.

*Horizon and locality.* Found in Assise E. 3 *e*. of the Upper Etcheminian, Dugald brook, Escasonie, Cape Breton, N.S.

" Distinguished from *Aparchites conchiformis* of the Protolenus Fauna, by its smaller size and prominent tubercle ; and from *A. secunda* by the tubercle and the coarser ornamentation," as well as by the angulated projection at the end of the valve.

An additional example of this species from the bed in which the original was found, and three others from a layer about a foot lower in the measures, give additional information of the species.

These examples are wider than the type. The ocular tubercle in this species is a little off from the hinge-line. The cardinal slopes are long and the anterior marginal slope is somewhat straightened.

The following are measurements of some valves :

| | | | | | | | | | | | Dimensions. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| right | valve, | length | 3¼ | mm., | width | 2¼ | mm., | depth | ¾ | mm. | |
| " | " | " | 3¼ | " | " | 2¼ | " | " | 1 | " | |
| " | " | " | 3 | " | " | 2 | " | " | 1 | " | |
| " | " | " | 3 | " | " | 2¼ | " | " | 1 | " | |
| " | " | " | 3½ | " | " | 2½ | " | " | 1 | " | |
| carapace | | " | 3 | " | " | 2¼ | " | " | 2 | " | |

## Mutations.

In the lower Etcheminian Fauna some forms occur which may be referred to this species as mutations.

### *Assise E. 1 b.* mut. OBESA.

Can. Rec. Sci. Montreal, 1902, p. 455.

Mutations of this species.

A broader and more tumid form than the type. The hinge-line is three-fifths of the length of the valve and there is a tubercle at the posterior end of the hinge line. The ocular tubercle is prominent and enclosed by the furrow ; a row of low and obscure tubercles runs curving from the ocular tubercle to the lower angle of the valve.

*Sculpture.* The surface is marked by a fine punctuation, and by anastomosing ridges on the posterior half of the valve ; a diagonal band of these ridges runs from the ocular tubercle, diagonally backward and downward to the lower part of the anterior margin.

*Size.* Length 3 mm., width 2½ mm., depth two valves together 1½ mm or more.

*Assise E 1. c.* A form occurs here which is flatter than the preceding and smaller.

This form differs from the young of *Bradorona observator* of the lower fauna in the deeper furrow around the tubercle, and in the rounder base of the valve ; hence we have associated it with *B. vigilans.*

*Assise E. 1. d.* An imperfectly preserved right valve was obtained here from beds of feldspathic sandy shale. It is considerably smaller than the type, and the surface is rough and dull from corrosion.

*Size.* Length of a valve 2½ mm., width 1¾ mm., depth ½ mm.

BRADORIA RUGULOSA, Pl. XIII, figs. 3 *a* to *d*.

*Bradoria rugulosa*, n. sp. Nat. Hist. Soc. N. B. Bull. iv, p. 205, pl. III, figs. 3 *a* to *d*.

Can. Rec. Sci. Montreal, 1902, p. 456.

"A suborbicular species of which only the right valve is known. Tubercle rather prominent, some distance below the anterior end of the cardinal line; this line is nearly straight and about half of the length of the valve. There is a faint furrow behind the tubercle. A narrow obscure marginal rim appears at the back of the valve.

*Sculpture.* The lower slope and the posterior half of the valve are covered with anastomosing ridges, concentric to the upper front part of the valve; toward the top and front of the valve these ridges become obscure and the surface of the valve is granulated.

*Size.* Length 2¾ mm., width 2½ mm., depth less than ½ mm.

*Horizon and locality.* In assise E. 3 *e.*, Upper Etcheminian Fauna, Dugald brook, Escasonie, Cape Breton, N.S. Rare.

"This little species is easily distinguished from others of the genus by its orbicular form and rugulose surface which is like that of certain trilobites."

MUTATION.

A small right valve of the form of this is found in Assise E. 1 *c* Lower Etcheminian, at Dugald brook. The punctuation is fine and distinct, and the rugulose surface is seen only near the margin of the valve.

BRADORIA ? ORNATA, Pl. XIII, figs. 4 *a* to *c*.

Can. Rec. Sci. Montreal, 1902, p. 456.

(?) The valves in this species are rather flat and are rounded to the hinge and lower margin, but not much to the ends.

Only one example known, which is supposed to be a right valve.

Suboval with a long hinge-line, about three quarters of the length of the valve. Anterior cardinal curve short, posterior longer. Anterior marginal curve long, rounded; posterior shorter, rounded forward. The

valve is more tumid in the cardinal third, and rounded to the hinge, where there is a low narrow ridge. A thread-like marginal fold is visible in some parts of the margin.

In this species there is no definite ocular tubercle, but a group of several small tubercles on a slight elevation, occupy its place. The ocular furrow is shallow, and close to the front of the hinge, and extends downward opposite the anterior cardinal curve.

*Sculpture.*—The surface is covered with distinct pits, the spaces between which become inosculating ridges, subparallel to the length of the valve, but tending downward in the direction of the front of the valve; towards the hinge line the pitting is very minute.

*Size.*—Length 2¼ mm., width, 1½ mm., depth of a valve nearly ½ mm.

*Horizon and locality.*—Assise E. 1 *c*, Lower Etcheminian Fauna, at Dugald brook, Escasonie, N.S.

The sculpture, something like that of an Entomis or a Kirkbya but finer, seperates this little species from the others.

## ESCASONA.*

Can. Rec. Sci., vol. VIII., 1902, p. 457.

Genus Escasona.

A few forms which cannot be referred to any described genus of the Eopalæzoic are present at two horizons in the Etcheminian. The typical form is in one of the highest beds of the Upper Etcheminian. It is short and high and the slight eminence which appears to indicate the ocular tubercle is close to the hinge. There is a long slope from the hinge toward the middle of the valve; it thus resembles Beyrichona; but it does not have the two strong furrows or pits near the hinge which characterize that genus; nor is the slope from the hinge so long. Though tumid in the upper third of the valve, this form cannot be classed with Schmidtella, because the slope in the upper third of the valve is not bent down abruptly to the hinge, as in that genus; and furthermore the outline of the valve is that of Beyrichona and Bradorona, and not the round valve of Schmidtella. I refer to this genus *Beyrichona ovata* of the Protolenus fauna. The typical characters of the genus are in the first of the following species, *E. rutellum.*

ESCASONA RUTELLUM. Pl. XIII, figs. 5 *a* to *c*.

Can. Rec. Sci. Montreal, 1902, p. 458.

Escasona rutellum.

A broad tumid species. Hinge two-thirds of the width of the valve. Anterior cardinal curve obsolete; posterior one-half of the length of the

* Named for the district of Escasonie in Cape Breton.

hinge, anterior marginal curve long, arched; posterior shorter, nearly straight, lower end of the valve obtusely pointed.

Highest point of the valve one-third from the hinge and two-fifths from the posterior margin. The ocular tubercle is small, close to the hinge and some distance from the anterior end. The posterior slope of the valve is flattened. The cardinal slope of the surface of the valve has a broad shallow furrow extending down nearly to the highest part of the valve. The arched anterior sloped surface of the valve is evenly curved down to the border.

*Sculpture.*—The surface of the shell has been corroded, and the pitted surface is obscure.

*Size.*— Length, 3 mm.; width, $3\frac{3}{4}$ mm.; depth, $1\frac{1}{2}$ mm.

*Horizon and locality.*—Assise E. 3*f*., Upper Etcheminian, at Gillis' Indian brook, Escasonie, N.S. Scarce.

ESCASONA (?) VETUS. Pl. XIII, figs. 6 *a* and *b*.

Can. Rec. Sci. Montreal, 1902, p. 458.

a (?) This form, represented by a right (?) valve, has a more rounded surface than the type, and the valve is flatter. No ocular tubercle is determinable. The hinge line is very long (sixth-sevenths of length) and there is a shallow furrow extending from it on the cardinal slope of the valve. The valve is most tumid toward the posterior (?) side; and the ventral angle is vertically behind the end of the cardinal line. A broad thickened band runs around the supposed posterior margin.

*Sculpture.*—The shell is minutely pitted, but it is mostly decorticated.

*Size.*—Length, 3 mm.; width, $3\frac{1}{2}$ mm.; depth, $\frac{3}{4}$ mm.

***Horizon and Locality.*—Assise E. 1 *d*. Lower Etcheminian, at Boundary brook, Escasonie, N.S.**

ESCASONA (?) INGENS, Pl. XIII. figs. 7 *a* to *c*.

Can. Rec. Sci., Montreal 1902, p. 459.

a (?) Only one valve known. The unusual form agrees with none of the other genera of the Etcheminian Ostracods. It appears to be a left valve and is so described here. The outline is obliquely subtriangular and somewhat wider than long.

The hinge line is three-quarters of the length of the valve; a shallow furrow runs parallel to the hinge, and near it for two-thirds of the length

of the valve. No ocular tubercle could be detected, but at what appears to be the posterior upper angle of the valve is a small tubercle. The anterior cardinal curve is short and nearly in the direction of the hinge; the posterior is wanting. The anterior marginal curve is long and strongly arched; the posterior is shorter and less arched, abruptly rounded below, and at a right angle with the hinge line. The valve is highest at the middle, gently arched toward the hinge, and to the lower margin of the valve, and more abruptly towards the anterior margin. A faint ridge or swelling runs along the back of the valve near the margin. Lower angle of the valve bluntly rounded. Traces of a narrow marginal fold are preserved in some places.

*Sculpture.*—The surface is corroded, and only in a few places can a fine punctation be seen.

*Size.*—Length, 6 mm.; width, 6½ mm.; depth, 1¼ mm.

*Horizon and Locality.*—In a fine gray shale, containing grains and lumps of calcium phosphate, included in the Coldbrook volcanic rocks at Dugald brook, Escasonie, N.S. Scarce.

This ancient Ostracod has the outline of a Beyrichona, but there is no flattened cardinal area of the valve, nor any trace of the deep muscle-pit of that genus. It is separated from Bradoria by the absence of ocular tubercle and posterior cardinal slope. It is provisionally placed in Escasona, though lacking the high elevation of the cardinal third of the valve, peculiar to the other species of that genus.

## INDIANA.*

Can. Rec. Sci., vol. VIII., 1902, p. 460.

Genus Indiana.

Two forms of Ostracods of the Etcheminian Fauna differ from any of the preceeding by their marked oval form and do not seem to fall into any of the later genera. The author has heretofore referred resembling forms to Aparchites and Primitia, but omitting from consideration the large size of most of the Basal Cambrian species, they also have usually a well developed ocular tubercle, or the rudiments of one.

In a decorticated example there is a faint muscle mark, where the muscle scar is placed in Bradoria and Bradorona, but it projects less toward the middle of the valve than in those.

The genus consists of large to medium-sized Ostracods, oval or ovate in form, the outline somewhat straightened along the hinge, somewhat sharply rounded at the anterior end, more broadly at the posterior. A ventral angle is scarce traceable, and the greatest fulness is in the post-

* Named for the Indian brook, on the branches of which these fossils were found.

erior half of the valve. The valves are evenly rounded, and highest about the middle. An ocular tubercle, or traces of one, can usually be seen in the upper anterior region of the valve.

Specie referred to it.

*Length* of the known species, 3 to 6 mm.

*Range.*—Through the Etcheminian and Protolenus Faunas.

Besides the species described below the following appear to belong here:

Primitia pyriformis. † } Both of the
P.——(?) fusiformis. * } Protolenus Fauna.

Aparchites (?) robustus † also of that fauna comes near this group.

Distinguished from other genera.

This genus is seemingly different from Nothozoe of Barrande. Nothozoe is an oval fossil occurring in the Ordovician of Bohemia, which the above author has referred doubtfully to the Ostracoda. The size, however, is much greater than that of the fossils we are dealing with here‡ and no ocular tubercle has been recognized. For these reasons, as well as on account of the obscurity of the characters of Nothozoe, it seems inadvisable to use this name for the Etcheminian species described below.

Equal objections may be taken to the referring of the Cape Breton species in question to the genus Primitia, or to Aparchites, which hitherto the author has used for the Lower Cambrian forms. The species of these genera are small, and the absence of an ocular tubercle in one, and the presence of a median sulcus in the other, are further distinctions from the species which the author has referred to Indiana. Few species of the genera Primitia and Aparchites attain a size in which the area of the valve is a tenth that of the shells referred to this genus.

INDIANA OVALIS. Pl. XIII, fig. 8 *a* to *c*.

Can. Rec. Sci., Montreal, 1902, p. 461.

Indiana ovalis.

**This species is ovate, broader behind than in front. Hinge line about one half of the length of the valve. Cardinal curves of moderate length. Anterior marginal curve long, arched; posterior short, more strongly arched. No marginal furrows seen. Ocular tubercle close to the hinge line; a narrow diagonal furrow behind the eye, extends to the lower end of the anterior marginal curve.**

*Sculpture.*—Along the lower margin are fine anastomosing ridges; the decorticated part of the valve shows the lower margin of a semi-circular muscle scar, directly behind the ocular tubercle, near the hinge line.

† Roy. Soc. Can. Trans., vol. iv, sec. iv, p. 132, pl. i, fig. 3 *a* to *c* and 4 *a* to *c*.

* N.Y. Acad. Sci., Trans., vol. xiv, p. 237, pl. vii, figs. 3 *a* and *b*.

‡ Individuals of *Nothozoe pollens* (Cyst. Silur. Bohm. vol. i, Supp. p. 536) have an area of valve 70 times greater than the largest species of Indiana.

Another example of the valve with the surface somewhat corroded shows small pits and also anastomosing ridges on the surface.

*Size.*—Length, 4¼ mm.: width, 3¼ mm.: depth of a valve, 1 mm. Another example is 3½ mm. wide.

*Horizon and locality.*—Assise. E. 1 *e*. Lower Etcheminian at Dugald brook, Escasonie, N.S. Scarce.

A form similar to this in size, though proportionately wider, occurs in the same assise; and another smaller, broader and flatter, is found in the assize E. 3 *e* Upper Etcheminian, at the same brook.

The following are dimensions of some valves:

Dimensions.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| E. 1 *e*. left valve, | length | 4½ | mm. | width, | 3¼ | mm., depth, 1 | mm. |
| E. 1 *e*. carapace, | " | 4½ | mm. | " | 3½ | mm., " 3¼ | mm. |
| E. 3 *e*. left valve, | " | 4½ | mm. | " | 3 | mm., " 1 | mm. |

Xestoleberis, Sars ('65), as represented by Prof. T. Rupert Jones' species *S. Wrightii*, from the Ordovician of Kildare, Ireland, is like this in form, but is more tumid, and is not shown to possess an ocular tubercle.

### Mutation PRIMA. Pl. XIII, 9 *a* to *c*.

Can. Rec. Sci., Montreal, 1902, p. 462.

Mutation prima.

A form resembling this species, but longer and larger, is found in the gray shale of the volcanic rocks. The example is a complete carapace, and the valves are crushed somewhat and displaced. There appears to be an ocular tubercle near the anterior end, and the fullest part of the valves is in the lower half.

*Sculpture.*—The surface is corroded, but there are traces of a fine punctation and of longitudinal striæ on the middle part of the valve.

*Size.*—Length of a carapace, 5½ mm.; width, 3½ mm.; depth 2¼.

*Horizon and locality.*—In fine gray shale in the midst of the volcanic rocks of the Coldbrook group of Dugald brook, Escasonie, N.S. Scarce.

### INDIANA LIPPA, Pl. XIII., figs. 10 *a* to *d*.

Can. Rec. Sci., Montreal, 1902. p. 463.

Indiana lippa.

Hinge line more than half of the length of the valve. Cardinal curves of moderate length; anterior marginal curve twice as long as the posterior, convexly arched. A very faint elevation in the position of the ocular tubercle: and a very shallow depression behind it. There is a thickened and slightly elevated band all around the margin, except at the hinge.

*Sculpture.*—The surface has been corroded, but there is a fine and rather distant punctation showing on one example; this becomes very fine towards the hinge-line, where anastomosing ridges are developed, running off toward the posterior slope of the valve.

This species differs from the type of the preceding one in its more elongate form, greater plumpness and obscure ocular tubercle.

*Size.*—Length, 4½ mm.; width, 2¾ mm.; depth, 2 mm.

*Horizon and locality.*—Assise E. 3 *f*, Upper Etcheminian, at Dugald brook, Escasonie, N.S. Infrequent.

## SCHMIDTELLA. Ulrich.

The two species referred to this genus are provisionally so placed, because they are tumid toward the hinge, and an ocular tubercle has not with certainty been observed. The broad valve, somewhat pointed below, however, is not a character of Schmidtella, and the valves are larger than is usual in that genus. If the tubercle were present, the following species might be included in Bradorona.

### SCHMIDTELLA (?) PERVETUS, Pl. XIII, figs. 11 *a* to *c*.

*Schmidtella? pervetus* n. sp. Nat. Hist. Sec. N. B. Bull. vol. iv., p. 206, pl. iv., figs. 3 *a* to *c*.

Can. Rec. Sci. Montreal, 1902, p. 464.

Schmidtella(?) pervetus.

"Only the right (?) valve is known [others found since.] The valve is moderately arched and without furrows, and its greatest fullness is in the upper half. The hinge-margin, which is more than half of the length of the valve, is straight and is formed by an infolding of the edge, which is without a furrow. No marginal fold was observed.

*Sculpture.*—The surface is covered with minute pits, closely placed; the raised spaces between the pits become so prominent on the lower part of the valve that the surface seems tuberculated, rather than pitted; toward the lateral and the lower edges these tubercles are arranged in rows, so that there the valve seems covered with obscure ridges parallel to the margin. At the opposite side of the valve, towards the hinge-line, the pits become very fine, and the surface of the valve has a shining appearance.

*Size.*—Length, 3 mm.; width, 2½ mm.; depth, 1 mm.

*Horizon and locality.*—In Assise E. 3 *e*. of the Upper Etcheminian, Dugald brook.

Some examples from the original bed show a valve highest in the middle, and with a hinge-line half of the length of the valve. There are traces of a narrow marginal fold.

"This species differs from *Bradoria rugulosa* in its coarser ornamentation and in the broader curve of the lower margin. "From *S. cambrica* of the Protolenus Fauna it differs in the less protuberant centre of the valve and the narrower and the straighter infolded border at the hinge-line. The marginal fold is also more distinct in *S. cambrica*, which does not have the concentric marginal ridges of this species.

Mutation CONCINNA, n. mut.

Can. Rec. Sci. Montreal, 1902, p. 464.

Mutation concinna.

Highest part of the valve about two-fifths from the hinge; evenly sloped to the margins, except that the anterior side is somewhat more turgid than the posterior. Hinge line about half of the length of the valve. A very narrow fold runs around the margin.

*Sculpture.*—Surface with a fine but distinct punctation that develops anastomosing ridges near the margins.

*Size.*—Length, 2½ mm.; width, 2½ mm.; depth of a valve, ⅝ mm.

*Horizon and locality.*—Assise E. 1 *d.*, Lower Etcheminian, at Boundary brook, Escasonie, N.S. Scarce.

This mutation is smaller and rounder than the type.

SCHMIDTELLA (?) ACUTA, Pl. XIII, figs. 12 *a* to *c*.

*Schmidtella acuta*, n. sp., Nat. Hist. Soc. N.B., Bull vol. iv. p. 206, pl. iv., figs. 4 *a* to *c*.

Can. Rec. Sci. Montreal, p. 465.

Schmidtella(?) acuta.

"Valves tumid. Hinge line somewhat more than half of the length of the valve, marked by a narrow fold and furrow that extends most of its length. Valves about as wide as long, somewhat acutely pointed at the lower margin. A narrow marginal fold extends along one side of the valve to the pointed end. Greatest protuberance of the valve in the upper half; toward the hinge the curve of the surface of the valve is turned somewhat abruptly inward toward the cardinal line."

This species has a small ocular tubercle.

"*Sculpture.*—The surface is smooth in appearance and somewhat shining, but under the lens is seen to be covered with minute pits or granulations, uniformly distributed."

*Size.*—Length, 2½ mm.; width, 2½ mm.; depth, nearly 1 mm.

*Horizon and Locality.*—In Assise E 3 *e* and *f*, Upper Etcheminian, at Dugald brook. Frequent.

The following are measurements of the valves of this species :

Dimensions.

E. 3 *e*, left valve, length 2¼ mm., width 2¼ mm., depth ⅓ mm.
E. 3 *e*, " " " 2 mm., " 1⅝ mm., " ½ mm.
E. 3 *e*, right " " 2⅓ mm., " 2¼ mm., " ⅝ mm.
E. 3 *f*, " " " 2¼ mm., " 2 mm., " ⅓ mm.

This species, by its smooth surface and pointed form, recalls the genus Beyrichona of the Protolenus Fauna; but it has not the broad flattened area, near the hinge which marks that genus; on the contrary it is there most prominent; this feature belongs to the genus Schmidtella.

"From *S. pervetus* this species is distinguished by its finer ornamentation and pointed lower margin; and from *S. cambrica* of the Protolenus fauna by its smoother surface and narrow fold at the cardinal line. No Silurian Schmidtella has the pointed valve of this species."

"HOLASAPHUS, Pl X., figs. 3*a* to *c*.

Trans. Roy. Soc. Can., 2nd ser., vol. 1, p. 268.

Holasaphus. Distinct from other genera.

"Among the fossils from Young point was a trilobite apparently related to Asaphus, but different from any described genus. From Bathyurus, Bill., it is excluded by the shallowness of the furrows on the head-shield, and the low relief of the glabella; it is shut out of Bathyurellus, Bill., by the narrow marginal fold and long axis of the pygidium; from Protypus, Walc., by its shorter glabella, inclined to conical, and the prolonged angles of the free cheeks; from Asaphiscus, Meek, by its Megalaspis-like pygidium; from Asaphelina, Mun-Cham. and J. Berg., by having only one spine to the pygidium; from Platypeltis, Call., by its shorter, cylindro-conical glabella, and markedly segmented and lobed pygidium.

"HOLASAPHUS CENTROPYGE, Pl. II., figs. 4*a* and *b*.

Holasaphus centropyge.

"Middle piece of the head sub-quadrate. Anterior margin with a distinct fold. Glabella sub-cylindrical, rounded in front, about one-quarter longer than wide, not furrowed. Occipital ring narrow, divided from the glabella by a narrow fold, and having an obscure tubercle at the back on the median line. Fixed cheeks slightly wider at the middle than half of the width of the glabella, widening before and behind the eyelobe, meeting in front of the glabella, furnished with short, prominent eyelobes, no ocular fillet. Posterior furrow and fold narrow, the former shallow.

Pygidium large sub-triangular, bordered all around, furnished behind with a sharp spine about one-third of its length. The axis is prominent and has three distinct rings and three obscure ones at the back of these; each of the front rings is furnished with a small tubercle at the back edge. The side lobes of the pygidium have four costæ and sometimes a fifth rib is obscurely shown; the furrows of the side lobes are straight and those toward the back are directed more and more backward.

*Sculpture.*—This consists of a fine granulation invisible to the naked eye.

*Size.*—Middle piece of the head—Length 10 mm. Width at the front 11 mm., at the back 15 mm. Pygidium length exclusive of the spine 9 mm., length of spine 3 mm., width 14 mm.

*Locality.*—Young point near George River station, Cape Breton.

Compared with other species.

The material on which the above description is based contains only the parts figured, and a large free cheek, which appears to belong to another species; it is similar to the cheek of an Angelina (Pl. II., fig. *b.*). The rock in which this fossil occurs is distorted by pressure and the figures are an average of several examples corrected for the distortion.

Dr. Jules Bergeron has decribed a Megalaspis from the Lower Arenig beds of the south of France, whose pygidium is similar to that of our species, but of which the head is unknown; his pygidium, however, is more exactly that of a Megalaspis.[1]

Mr. Walcott has described a pygidium from the Pogonip group of Eureka, Col., *Bathyurus congeneris*, with a broken spine which is like ours, but it lacks the border-fold.[2]

*Bathyurus caudatus*, Bill., from the G-A beds of the Quebec group in northern Newfoundland, based on a pygidium only, resembles our species in the number of segments in the pygidium and in possessing a terminal spine, but it has no furrow within the border."[3]

Movable cheek.

Since the above description was written, the *movable cheek* of this species has been obtained. It is long, rather narrow behind, and terminates in a long slender genal spine about half of the length of the cheek. There is a marginal fold which is about half as wide as the inner area of the cheek at the eye-lobe; at the front it extends into a doubleur that passes beneath the front of the middle piece of the head shield. The inner margin of the cheek is not well preserved in the examples known, but the extension of the sutural line, both in front and behind the eye-

[1] Massif Ancien au sud du Plateau Central. p. 340, Pl. iv., figs. 3 and 4.
[2] Palæontology of Eureka District. Pl. viii., figs. 8 and 8*a*.
[3] Palæozoic Fossils. p. 261, fig. 245.

lobe, appears to be convex. The genal spine is directed somewhat outward from the regular curve of the folded margin of the cheek.

*Horizon.*—Calciferous sandstone bed of E. 2 (a?) at Young point.

[redacted] PARADOXIDOID TRILOBITE. Pl. XI. Figs. 1 *a*—*e*.

Trilobite resembling Paradoxides.

Parts of a large trilobite were obtained from the sandy shale that holds the last named species, but there was not enough of the middle piece of the head to determine the genus. The known parts are such as might be found in a Paradoxides having long eyelobes, and as belonging to so old a fauna, these fragments are of especial interest. The parts indicate a species as large as *P. eteminicus* or *P. micmac.* The form of the pygidium indicates that the thorax possessed long, backward-bent posterior pleuræ.

*Sculpture.*—The matrix is so coarse that but little of the ornamentation is preserved. It may be said, however, that the movable cheeks were marked by sub-parallel anastomosing raised lines, about 4 or 5 in the space of a millimetre. The doubleur was also ornamented with parallel raised lines.

The movable cheek of an unknown trilobite, figured with the original description of *Holasaphus centropyge*, is probably of this species. The parts found are part of a glabella and of the movable cheek, two pygidia, and various body segments.

*Horizon and locality.*—In sandy shale at Young point, George river, Cape Breton, N.S.

SOLENOPLEURA BRETONENSIS, n. sp. Pl. XI., Figs. 5 *a*—*c*.

Solenapleuro (?) Bretonensis.

The middle piece of the head-shield is trapezoidal in outline. Anterior marginal fold prominent; front area of the cheeks long, convex, and as wide as one-third of the length of the glabella. The *glabella* is ovate, enclosed by deep dorsal furrows, and having a strong occipital furrow; three slightly impressed lateral furrows are formed on the glabella, of which the posterior arises opposite the middle of the fixed cheek, and curves backward nearly to the occipital furrow; the middle furrow appears a little behind the ocular fillet, and has a curve similar to that of the posterior furrow; the anterior furrow is opposite the ocular fillet, is short and turns somewhat forward; thus the two anterior furrows are close together. The occipital ring is about as wide as the front area of the cheek, is well rounded and has no spine. *The fixed cheek* has a distinct ocular fillet, and a long eyelobe; it is tumid, but depressed con-

siderably below the glabella; a deep furrow at the back corresponds to the occipital furrow.

A movable cheek supposed to be of this species, found in the same assise, but at a different locality, has a correspondingly long eyelobe curve, and is remarkable for the wide and high marginal fold; this is as wide as the area of the cheek at the middle; there appears to have been no genal spine, but the lower outer corner of the cheek was bluntly pointed.

Detached pleuræ occuring with the parts of this trilobite are like those of Ellipsocephalus, bluntly rounded at the end, and have a straight furrow deepening toward the end.

*Sculpture.*—The middle piece has a finely granulate surface; the movable cheek appears to be more coarsely granulated, but this appearance may be due to the coarseness of the matrix.

*Size.*—Length of the middle piece of the head-shield 12 mm., width at the front 11 mm.; at the back about 19 mm. Length of the movable cheek 12 mm.; width 5 mm. Length of a pleura 6½ mm.; width 2 mm.

*Horizon and locality.*—Assise E. 3 *f*. Upper Etcheminian Fauna. The heads from Gillis, Indian brook, the movable cheek and pleura from Dugald brook, Escasonie, N.S.

This species is referred to Solenopleura on account of the deep dorsal furrows and occipital furrow, absence of occipital and genal spines, prominent and rounded glabella, convex front area to the middle piece of the head-shield, and strong eyelobe and fillet.

It differs from all the species of Solenopleura of the Paradoxides Beds by its long eyelobe. If it were not for this it would be near *S. brachymetopa* Ang. var. as figured by Dr. Brögger.*

Taken alone the movable cheek referred to, this species compares best with that of an Anomocare, a genus of the Upper Paradoxides Beds of Sweden. Resembles an Anomocare.

### Eurypteroid Crustacean? Pl. XI. fig. 3.

A broken piece of the test of a crustacean was collected at Gillis Indian brook, which simulates the head-shield of a Xyphosuroid crustacean. If not this it is the axial ring of a trilobite, which bore paired tubercles near the middle of the ring; it is abraded at the front. Doubtful Eurypteroid crustacean.

* Om Paradoxides skifrene ved Krekling. Christiania, Nyt Magazin 1878.

The test is narrowly semicircular, is moderatly arched in front and at the sides, but had a steep slope behind where it was attached to the next joint of the skeleton.

Nearly half way from the back on the right side there is a prominent circular tubercle, and in a corresponding position on the left side an abraded space of similar form. Faint furrows go out from those tubercles, in front and behind them, toward the lateral margins of the test.

The apparent eyelobes in this test are in about the position of the eyes of Limulus, but farther back than the normal position in Eurypterus. Aglaspis of Hall, from the Upper Cambrian of Wisconsin, has circular eyes like the tubercles in this test, but they are much closer together, and nearer to the front of the shield.

*Sculpture.*—The surface is very finely granulate and punctate.

*Size.*—Length, 7 mm.; width, 10 mm.

*Horizon and locality.*—Sandy shale of Assise E. 3 *f* at Gillis, Indian brook, Escasonie, N.S. Rare.

Dr. J. C. Moburg has described a fossil from Sweden found in a horizon corresponding to the Etcheminian terrane, which is not unlike this.* He refers it doubtfully to the genus Kutorgina. Only casts of the organism have been obtained, so that the texture of the test is unknown. It has round tubercles corresponding to the supposed ocular tubercles of this form, but they are more anterior and closer together and so are more nearly in the position where the eyes of the Silurian Eurypteroids are placed. This species is represented as having a raised rim and is more elevated behind than the Cape Breton form, but the articulating slope is not so strongly marked.

The two Etcheminian faunas, shown together in the above descriptions, may be divided as follows:

teristic of the chemi- nas.

| *Lower Fauna.* | *Upper Fauna.* |
|---|---|
| Acrothyra signata. | Acrothyra proavia. |
| A. ——————— sera. | A. ——————— prima. |
| A. ——————— tarda. | A. ——————— crassa. |
| A. ——————— orta. | Acrothele avia. |
| Acrotreta papillata. | A. ——————— patula. |
| A. ——————— lata. | A. ——————— arcuata. |
| Leptobolus cf. collicia. | A. ——————— prodeta. |

*Om en nyupptäckt fauna i block of Kambrisk Sandsten (Geol. ... Bd. 14 Häft 2, 1892.

| *Lower Fauna.* | *Upper Fauna.* |
|---|---|
| Lingulella Selwyni. | Leptobolus atavus. |
| L. ——— cf. tumida. | L. ——— insulæ. |
| L. ——— longovalis. | L. ——— tritavus. |
| Lingulepis Gregwa. | L. ——— collicia. |
| L. ——————— robusta. | L. ——————— collis. |
| L. ——— Roberti. | Lingulella tumida. |
| L. ——— longinervis. | |
| Obolus (Eoobolus) æquiputeis. | Obolus Palæobolus Bretonensis. |
| O. (E.) —— discus. | |
| O. (E.) —— triparilis. | O. (P.)——————— lens. |
| Billingsella retroflexa. | O. (P.)——— — — lens-longus. |
| Bradorona perspicator. | |
| B. ——————————— maxima. | Leperditia (?) rugosa. |
| B. ——————————— magna. | Bradorona perspicator—major. |
| B. ———spectator. | Bradorona spectator—æquata. |
| B. ——————————— acuta. | B. ——— observator—ligata. |
| B. ——————————— spinosa. | Bradoria scrutator. |
| B. ——— observator. | B. ——— vigilans. |
| B. ——————————— benepuncta. | B. ——— rugulosa. |
| B. ——————————— lævis. | Escasona rutellum. |
| Bradoria vigilans-obesa. | Indiana ovalis. |
| B. ——(?) ornata. | I. —— lippa. |
| Escasona rutellum-prima. | Schmidtella (?) pervetus. |
| E. ——(?) vetus. | S. ——————— (?) acuta. |
| Indiana ovalis. | |
| Schmidtella (?) pervetus-concinna. | |
| Holasaphus centropyge. | Solenopleura Bretonensis. |
| Paradoxidoid trilobite. | Eurypteroid crustacean ? |

In addition to remarks made in the text of this report on the characteristics of the two faunas it will be seen that Lingulepis particularly characterizes the Lower fauna and Leptobolus the Upper.

## FAUNAS OF THE ST. JOHN TERRANE.

the As the faunas found in the St. John terrane in Cape Breton were not separately of very many species, they are here described collectively, with reference at the end of each species to the fauna to which they belong.

While Brachiopods form the bulk of the Etcheminian fossils in Cape Breton, Trilobites show in considerable abundance in some of the zones of the St. John terrane, and are of varied types. The lower zones, so far as this exploration went, did not produce many fossils, although at a few places some forms of the Paradoxides fauna were found, and in places the middle zones yield an abundance of the Inarticulate Brachiopods.

The middle zones here, as in New Brunswick, abound in ripple-marked beds filled with worm burrows, and bear other evidences of shallow-water origin. These have a fauna of Atrematous Brachiopods that is quite like that of the corresponding measures in New Brunswick.

There is also similarly a return to deep water beds in the upper part of the terrane, and with the dark gray shales of this portion, appear faunas similar to those known from this part of the terrane in New Brunswick. This part, though comparatively thin, has three Upper Cambrian faunas, so that it represents nearly as wide a period of time as similar shales in New Brunswick. These three faunas are those of Peltura, Dictyonema and Asaphellus. The latter being known in England as the Tremadoc fauna. In the edition of Dana's Geology of 1875 this group (the Tremadoc) is classed as Silurian (*i. e.* Ordovician). In the later edition, 1896, it is transferred to the Cambrian. Prof. Jas. Hall referred species of this fauna from the sandstones of the Mississippi valley to the Potsdam (therefore Cambrian) in 1863? Mr. C. D. Walcott has referred strata in the west of America and at Saratoga, N. Y., holding this fauna, to the Potsdam or Upper Cambrian. But in Europe the consensus of opinion (omitting Great Britain) places this fauna in the Ordovician or Lower Silurian. Lindström says that in Sweden not one species passes from the Cambrian to the Ceratopyge Fauna (*i. e.* the Tremadoc) while nineteen species pass from the Ordovician to the Silurian (Upper). Four species, however, are recorded as passing in Wales from the Lingula Flags to the Tremadoc Group.* Elsewhere it is stated that 6 out of 37 species of crustacea pass from the Tremadoc to the Arenig in Wales.† So that it is difficult to draw a line of absolute division between Cambrian and Ordovician, either above or below the Tremadoc.

* Mem. Geol. Surv. G. B., vol. iii, p. 365, etc.
† Ibid. p. 353.

On the whole it seems better to hold to the prevalent English opinion which places the line of the division above the Tremadoc, notwithstanding the conditions that prevailed in Northern Europe, and notwithstanding the fact that new and important genera of crustaceans appeared in the Tremadoc slates. To adopt the line drawn by the palæontologists of Scandinavia and Germany would make necessary a revision of the Cambrian geology of America, whereby large areas and extensive faunas that have been classed as Cambrian would of necessity be transferred to the Ordovician, or Lower Silurian. Further, it may be inferred that this hiatus in the faunas will be bridged over by the discovery of connecting faunas in the strata of some other region than that of Europe. The Mount Stephen fauna, for instance, in British Columbia, associates genera of Ffestiniog, Dolgelly and Arenig types, and generally in the Rocky Mountain region there is a blending of Cambrian and Ordovician types. For these reasons it seems undesirable to abandon the old classification which drew the dividing line at the base of the Arenig, and made the appearance of the Arenig graptolites the starting point of a new system.

The beds from which this fauna was taken appear in outcrops along the left bank of McLeod brook, in Boisdale, Cape Breton, N.S., the best locality being about an eighth of a mile below the bridge that crosses that stream in McMullin settlement. The rock is a soft, fine-grained, dark gray shale, not very different in appearance from that which, on the opposite side of the valley of McLeod brook, carries the Dictyonema fauna. The rock easily softens when exposed to the weather, but is compact and firm lower down. The classes and phyla represented here are Brachiopoda, Lamellibranchiata, Gasteropoda, Vermes and Crustacea.

If one were to be governed by stratigraphical considerations alone, the indications would rather place the Tremadoc fauna of McLeod brook below the Dictyonema fauna than above it, as it lies to the north of that fauna, and on the north side of the McLeod brook valley the lower Cambrian strata are found, but the close folding of the measures and the variable dips make the stratigraphy an unreliable guide for the minuter groups within the divisions. We assume therefore that this fauna represents the highest portion of the St. John terrane present in Cape Breton.

The following species described in this report, came from the Tremadoc horizon.

Species of this fauna.

Urotheca.
Acrotreta sipo.
Leptobolus cf. linguloides.
Bellerophon semisculptus.
Parabolinella quadrata.
P. ——— cf. limitis.

| | |
|---|---|
| Lingulella cf. Davisii, Salt. | Triarthrus Belli. |
| L. ——— cf. lepis, Salt. | Angelina (?). |
| Modiolopsis cf. solvensis, Hicks. | Asaphellus Homfrayi var. |
| Bellerophon insulæ. | A. ——— planus. |
| B. ——— Bretonensis. | |

ctyone-ia. The Dictyonema fauna, like that of the Tremadoc group, has so far been recognized only in the valley of McLeod brook, and is found in similar gray and dark gray shales. The species are:—

| | |
|---|---|
| Dictyonema flabelliformis Eichw. | Lingulella concinna. |
| Acrotreta bisecta. | L. ——— cf. lepis. |
| Schizambon priscus. | Linnarssonia cf. Belti. |
| Leptobolus gemmulus. | Monobolina refulgens. |

ltura The Peltura zone gives a more varied fauna, which is contained in similar slates with some thin limestone bands.

| | |
|---|---|
| Lingulella (Westonia) Escasoni. | Parabolina Dawsoni. |
| Orthis lenticularis. Wahl. | Sphærophthalmus Fletcheri. |
| Camarella (?). | S. ——— alatus. Boeck. |
| Agnostus sp. | Ctenopyge pecten. Salt. |
| A. —— trisectus-ponepunctus. | Peltura scaraboides. Wahl. |
| A. —— ——— —germanus. | |

rab-una. There seems to be a somewhat abrupt transition from thin flags and sandstones below the Peltura horizon to the assise which contains that fauna. It is marked on East bay by the occurrence of a calcareous sandstone full of phosphatic lumps and nodules, and with ripple marked layers. This would indicate deposition in shallow water near a shore line, whereas the fossils of the underlying Peltura beds indicate rather deep water and quiet seas. Unless there is a break in the succession here, such as we have not observed elsewhere, these thin flags and phosphatic layers should represent tho Parabolina zone. The fossils are:—

Lingullella lævis var, grandis, and var. lens.

The band below, Assise C. 2, c. has yielded fossils in the valley of the Mira river, where there are a few species of small size, viz:—

| | |
|---|---|
| Lingulella radula, var. aspera. | Lingulepis rotunda. |
| Leptobolus flumenis. | |

per xides The middle members of this division of the St. John terrane though showing an abundance of fossils, present them only in small variety.

The species are as follows:—

| | |
|---|---|
| Lingulepis Starri, var. | Beyrichia triceps. |
| L. ——— —— var. exigua. | Paradoxides Forchhammeri, var. |
| Lingullella sp. | Ctenichnites bisulcatus (track). |
| Obolus sp. | |

Considering the fineness of the shales of the lower division (Acadian) of the St. John terrane, it is singularly deficient in fossils. Among those found were: The Lower Paradoxides fauna.

| | |
|---|---|
| Palæacmea sp. | Ptychoparia sp. |
| Agnostus, sp. (longifront). | Paradoxides cf. rugulosus. |

## DESCRIPTION OF THE SPECIES.

### Urotheca, sp., Pl. XVIII., fig. 6.

Bull. Nat. Hist. Soc. of N. B., No. iv., p. 411, pl. xviii, fig. 6.

A thin chitinous tube, seemingly of this genus, occurs sparingly. It is thickened along one side and is marked by very minute longitudinal striæ.

*Horizon and locality.*—Fine gray shale of C. 3 $c^2$. McLeod brook, Boisdale, N.S.

### Acrotreta *cf.* socialis. vonSeebach. Pl. III., figs. 5 *a-k.*

*cf. Acrotreta socialis*, v.Seeb., Zeitschr. der Deutsch. geol. Gesellschft., Vol. xvii, 1865, p. 341, pl. viii, *a*, figs. 1-4.

*cf. Acrotreta socialis*, v.Seeb., G. Linnarsson, 1898, Brachiopods of Paradoxides Beds of Sweden, Bihang till K. Svenska vet. Akad-Handl. Bd. 3 No. 12, p. 16, Tafl. iii, figs. 32-34.

Bull. Nat. Hist. Soc. of N. B., No. iv., p. 392, pl. xv., figs. 5 a-k.

A small species with coarse surface characters and strong muscle scars. Acrotreta cf. socialis described.

*Ventral* valve moderately elevated, sub-circular in outline, somewhat flattened on the cardinal slope, where, in outline, it is slightly convex; nearly straight in the anterior slope. *Interior*—At the back there are one or two faint grooves on the median part of the cardinal slope; the foraminal boss is a wedge-shaped one with the point directed forward; this is enclosed by two sub-parallel, deep, rounded pits, for attachment of muscles. Behind the foramen is the back of a ridge, similar to a crescent, that encloses the apical part of the shell behind, and laterally; in the

front half of the space thus enclosed is a faint outline of a visceral callus of a lozenge shape. The position of the vascular trunks is probably outside of the horns of the crescent, thence extending forward; about a third or a quarter from the front of the shell is a crescentic row of short vascular grooves. In front of this row of grooves are one or two growth ridges, and the flattened border of the valve.

The *dorsal* valve is orbicular in outline; its height is less than half of that of the ventral. The valve is strongly arched in the posterior half, but somewhat flattened on the posterior lateral slopes. *Interior.*—This is marked by three strong radiating ridges in the posterior half of the valve; at the origin of these ridges are a pair of pits with a small tubercle in each, marking the position of the cardinal muscles. Of the three radiating ridges, the central is a narrow median ridge, with three sharp keels; for half of the length of the valve this ridge is prominent, but fades away in the anterior third of the valve; at the end of this ridge would be the scars of the anterior laterals ("j."). The lateral ridges are broader than the mesian one, but not so long; outside of them are the impressions of the lateral muscles.

*Sculpture.*—The roughness of the matrix prevent a good presentation of the surface characters of this species. Some examples of the ventral valve show fine concentric ridges, of which there are about ten in half the length of the anterior slope (*i. e.* about 10 to 1 mm.); the surface of these ridges appears to be granular.

*Size.*—The largest dorsal observed was 3 mm. across, but the greater number are not more than 2 mm. The full-grown ventral is about 2 mm. high, and the dorsal less than one.

*Horizon and locality.*—In gray flags of Div. 2c on the eastern slope of the valley of McNeil brook, on the road to Trout brook. Found in various attitudes in the sandy bed. The ventrals are both upright, inclined, and lying on their sides in the layers. From this locality Mr. Fletcher has reported Obolella, a genus in which, at the time his report was written, many of these small brachiopods of the Canadian Cambrian were included.

rison her

Linnarsson described very fully a species like this from the Paradoxides beds of Sweden.* He found it to range through the whole of the Paradoxides zone. Our form belongs somewhat higher up.

From *A. Baileyi* of the (lower) Paradoxides beds in New Brunswick† this species is distinguished by its smaller size, and as to [illegible] by

* Loc. cit.

† Trans. Roy. Soc. Can., Vol. iii, sec. iv, p. 36, pl. v, figs. 13, 13a [illegible]

its narrow umbonal ridge to the ventral valve, higher cardinal area, and by the longitudinal pits that enclose the umbonal ridge. It differs from *A. gemmula* of the Protolenus fauna‡ (see Pl. III., figs 4 *a-d*) in the sharp umbonal ridge of the interior of the ventral, and by the strong lateral ridges of the inside of the dorsal valve. From *Acrothyra proavia* of the Etcheminian fauna§ (see Pl. II., figs. 2 *a-g*) it is distinguished by the more central apex of the ventral valve, and by the prominent ridges of the interior of the dorsal valve, as well as by its larger size. From *A. gemma*, Bill. (Walcott)¶ it is distinct by its smaller size, less proportionate height of the ventral valve, its narrow umbonal boss and its more obscure cardinal area, also by a difference in the internal markings of the dorsal valve.

### Acrotreta sipo, Pl. XVIII. figs. 1 and 2.

Bull. Nat. Hist. Soc. of N.B., No. iv. p. 406, pl. xviii figs. 1 and 2.

Acrotreta sipo described.

A small species with somewhat overhanging umbo.

*Ventral valves* nearly as high as long. Umbo projecting behind the cardinal line, somewhat bluntly pointed, (some valves are trumpet shaped toward the margin) and a little broader than long. *Interior.* The foramen passes outward through a short siphon which is attached to the dorsal side of the valve; on each side of it are traces of lateral septa; in front of it is the faint impression of a callus which extends one-third of the distance to the anterior margin.

The *dorsal valve* is transversely oval, and arched from hinge to front, more strongly toward the hinge; the lateral edges are flattened, especially toward the hinge. *Interior.*—This shows traces of scars of lateral (?) muscles on each side of the umbo, and of a pair of central muscles near the middle of the valve. A distinct, though low, median septum crosses the valve nearly to the front margin.

*Sculpture.*—No concentric striæ were observed on this species, but the surface of the valves is minutely granulated.

*Size.*—The largest ventral observed had a size at the orifice of 3 x 3 mm., and others a height of $2\frac{1}{2}$ mm. A dorsal was $2\frac{3}{4}$ x $3\frac{1}{2}$ mm.; height $\frac{3}{4}$ of a mm.

The siphon is seldom preserved.

Three quarters of the ventral valves collected stand vertically in the mud in which they were entombed.

‡ Trans. New. York Acad. Sci. xiv, p. 126, pl. v, figs. 5 *a-d*.
§ Bull. Nat. Hist. Soc. N.B., vol. iv, p. 203, pl. iii, figs. 2 *a-f*.
¶ Bull. U.S. Geol. Surv. 30, p. 98, pl. viii, figs. 1, 1*a-b*.

*Horizon and locality.*—Gray shales of the assise C. 3 $c^2$, at McLeod brook, Boisdale, N.S.

This little shell seems to throw light on the function of the callus in Acrothyra and Acrotreta. In ordinary species of Acrotreta the strong thickened ring around the foramen, within the shell, only needs to be raised still further to produce a siphon. And the siphon in this species, attached as it is to the dorsal side, holds the position of the callus in Acrothyra.

This must be near in age to *Acrotreta gemma* of Billings, than which it is a little larger, but as we do not know anything of the interior of Billings species (which belongs to the Arenig horizon) we do not use his name.

ACROTRETA BISECTA, Pl. XI. figs. 5*a-g*.

Bull. Nat. Hist. Soc. of N. B., No. iv. p. 275, pl. xvi. figs. 2*a-g*.

Shell substance thin, calcareo-corneous. Outline of the valves, oblately circular.

*Ventral valve* elevated conical. Height about one-quarter less than the width. The umbo is about a quarter of the length of the valve from the posterior margin. The valve is somewhat flattened on the posterior slope at the cardinal area, which is nearly as long as half the width of the valve, and has a deltidial area, bounded by distinct furrows; elsewhere the valve slopes regularly to the margin. *Interior.*—The mould is always truncated and has a somewhat convex summit; in some examples there are traces of one or two diaphragms extending across or into this part of the valve, from the anterior slope. A crescent-like ridge extends around the back of the summit of the mould and down the lateral slopes. Towards the front of the valve a pair of low ridges radiate toward the front of the mould, but fade out at one-quarter from the anterior margin.

The *dorsal valve* is most convex at the back, where the slope is nearly vertical; it has a long flattened slope to the front. *Interior.*—The mould of this species is marked by a long, deep, narrow furrow (indicating a strong mesian ridge); this is somewhat broader in the anterior third than elsewhere; the mould also has two pairs of pits near this furrow, which perhaps indicate the position of the central muscles: the posterior adductors are indicated by bosses on the mould near the cardinal line, and the lateral muscles by depressions near the ends of the cardinal area. Fine radiating vascular lines are visible in the front half of the valve on each side of the median ridge. In young valves this ridge is only two-thirds of the length of that in the adult valve, the anterior third being smooth.

[illegible] New York State Geologist's Report, 1891, Hall & Clarke, p. [illegible]

*Sculpture.*—The surface is marked by minute concentric beaded ridges, visible only with a strong lens; there are stronger growth lines at intervals.

*Size.*—Length, 3 mm. Width 3¼ mm. Height of the ventral valve, one-fifth to one-quarter less.

*Horizon and locality.*—The fine dark gray shales of the Dictyonema beds (C. 3c.) at McLeod brook, Cape Breton.

Compared with other species.

On re-examining the specimens from this horizon at Navy island, St. John, N.B., which I had compared with *A. Baileyi*, of the Paradoxides beds, I find they are of a species identical with that from McLeod brook. It is distinguished from *A. Baileyi* by the long, sharp median ridge of the interior of the dorsal valve; the convex summit of the mould of the ventral valve also distinguishes it from that species, in which the summit is concave, and porportionately smaller.

From *A. socialis*, Von Seebach,* this species is distinguished by its somewhat larger size, and by the absence of the sharp wedge-shaped furrow in the top of the mould of the ventral valve; by the absence of the strong lateral furrows in the mould of the dorsal valve of that species; also by the deeper and longer mesian furrow of the dorsal valve of the McLeod brook species.

From *A. gemma*, Walcott,† this species is distinct by the convex top of the mould of the ventral valve, by the absence of an area to the dorsal valve, and the enlarged posterior end of the median ridge in this valve.

From *A. gemmula*‡ this species is distinct by the larger size, convex summit of the ventral mould; and by the smaller scars of the posterior adductors and sharper and longer median ridge of the dorsal valve.

### Schizambon Priscus, Plate xi., figs. 6*a-d.*

Bull. Nat. Hist. Soc. of N. B., vol. iv, p. 277, pl. v., figs. 4 *a* to *d*.

Shell substance firm, corneous (or calcareo-corneous?). Outline orbicular, and valves lenticular and of moderate depth.

Schizambon priscus described.

*Ventral valve* with a rounded umbo, the greatest depth in front of the umbo, about two-thirds from the front. About one sixth or one eighth from the posterial margin, the valve is perforated by an oval foramen, in

*Brachiopoda of the Paradoxides beds of Sweden. G. Linnarsson, Stockholm, 1876, p. 16, pl. iii, figs. 32-35.

†U. S. Geol. Surv. Bull. No. 30, p. 98, pl. viii, figs. 1*a-b*.

‡Roy. Soc. Can. Trans., vol. xi, sec. iv, p. 87, pl. xvi, fig, 2*a-d*.

front of which two narrow diverging ridges run forward to the front of the valve, where they are about as far apart as one-quarter of the length of the valve. There is considerable variation in the size and position of the foramen in the example collected. *Interior.*—The foraminal passage is smaller within than at the outer surface of the shell, and is surrounded by a raised rim; from it two thread-like grooves run forward into the front of the umbonal cavity. (The ridges that run forward from the foramen on the outer surface of the shell are preserved as grooves on its inner surface.) The visceral callus, of a lenticular outline, extends about half as far in front of the foramen as that is from the posterior margin; it is crossed by two faint diverging ridges on each side, and is bordered by two stronger lateral ridges, widely diverging, that mark the position of the lateral muscles; the length of these ridges is about one-third of that of the shell. Faint traces of vascular trunks are found in the lateral and posterior part of the shell and make a regular arch about one-sixth of the length of the shell, from its margin. The margin is flattened, especially in the posterior half, toward the umbo.

The *dorsal valve* is flatter than the ventral, and its umbo somewhat removed from the posterior margin. The central part of the valve has a flattened triangular space extending back towards the umbo; as the lateral margins are flattened in the posterior half, a low flattened ridge extends out on each side from the umbo to the mid-length of the valve. *Interior.*—This shows a broad flattened mesian ridge extending half way across the valve from the posterior margin, on each side of this, about one-third from the back of the valve, and nearly as far apart, are obscure oval marks, probably indicating the position of the anterior adductor muscles. The margins of the valve are flattened behind. *Sculpture.*—This consists of sharply defined but very minute concentric and radiating ridges that form a delicate cancellated pattern: on the highest part of the shell the concentric ridges are most distinct, on the front part, the radiating ridges. No cicatrix marking the advance of the foramen was observed, but a progressive change of this kind is probably indicated by the paired thread-like ridges behind the foramen on the interior of the ventral valve.

*Size.*—Length and width each 4 mm. Depth about [illegible] that of the dorsal valve less.

Compared with other species.

*Horizon and locality.*—Fine dark gray shales of the [illegible] (C. 3*c*) at McLeod brook, Cape Breton.

This pretty little species is the smallest and oldest known of its genus. Mr. Walcott indicates for *S. typicalis* a calcareo[illegible] shell, [illegible]

[illegible] U. S. Geol. Surv. Monogr. viii, p. 70, pl. 1, figs. 5, [illegible]

while there may be an outer calcareous layer to *S. priscus*, it has not been detected. From the former species, which is Ordovician, it differs not only in its small size, but its orbicular form; it differs also in having radiating as well as concentric striæ on the outer surface. It is much smaller than Dr. Ami's *S. Canadensis* of the Utica shale.

In one example of the ventral in this species the foramen is in the umbo, but in the others it is in front of it. The ring around the inside of the foraminal opening is never prolonged into a tube as in Siphonotreta.

In re-examining the material from this horizon at Navy island, St. John, I find that this species is present there also, but the surface marking are not well preserved; however, the form and size of the shell, and the foraminal opening, show it to be the same species.

LEPTOBOLUS FLUMENIS, n. sp. Pl. XI. figs. *a—f*

A narrowly ovate species, somewhat straight on the sides, and broadly rounded in front. Leptobolus flumenis described.

The ventral valve has an obtusely pointed beak, bent down at the apex. Sides of the valve somewhat sharply sloped in the posterior half and gently sloped in front. *Interior.* This shows an area nearly half a millimetre long, and a visceral callus extending about half the length of the valve. The lateral ridges within the valve extend as far; and in front of them, reaching to within a sixth of the length of the valve from the front, are a pair of arched vascular groves, not far from the margin of the valve; numerous external branches from these trunk grooves extend to the flattened margin of the valve; the individual length of these branches is about equal to the width of the main groove.

The dorsal valve is obtusely rounded at the hinge area, which is very short, and here and at the sides the valve is strongly arched downward, but is gently sloped down in front. *Interior.*—In front of the linear cardinal area is a pair of pits marking the insertion of the cardinal muscles. The middle of the valve for more than half the valve's length has a flattened band marking the progress of the central muscles during the growth of the shell. At the front this band is about one sixth or one eight of the width of the valve, and at its sides are faint prints of the central muscles; and at the front are two pairs of minute pits, one or both of which marks the position of the anterior laterals. The place of the posterior laterals is marked by a series of small pits near the margins in the posterior third of the valve. In front of these pits are the strong arched grooves left by the vascular trunks, which extend across the middle half of the valve near its margins.

*Sculpture.*—No examples have been obtained showing the surface markings, except those near the front of the valve; but both valves show from four to six ridges of growth in the anterior quarter of the valve; these ridges are broadly curved in the middle part, but more abruptly at the sides.

*Size.*—Ventral valve 4 mm. long and 2½ mm. wide. The dorsal valve is nearly one half millimetre shorter than the ventral.

Compared with L. insulæ.

*Horizon and locality.*—In grey flags of the Middle Cambrian (Div. 2 *c.*) on the eastern slope of the valley of McNeil brook (on road to Trout brook) Mira river, N.S.

This species is of nearly the same size as *L. insulæ*, but is less elliptical in outline, and the valves are more flattened in front; the area of the ventral valve also is longer, and that of the dorsal shorter than in that species; also the central group of muscles is not set so far forward as in that of the dorsal of the species cited.

This species differs from *L. atavus* of the Etcheminian terrane in having the central muscles of both valves set farther back.

LEPTOBOLUS GEMMULUS, Pl. XIV., figs. 1*a* to *c*.

*Ob lella ? gemmula*, Trans. Roy. Soc., Can., vol. ix, sec. iv, p. 41, pl. xii, figs. 8*a-c*.

Leptobolus gemmulus described.

The following is the original description of this species :—

Ovate acuminate, sides somewhat straight in the posterior half, rather broadly rounded in the anterior half of the shell. Test, calcareo corneous.

Ventral valve acuminate behind; it has a small triangular area, with pedicle groove and low beak. The *interior* of the valve has a ridge, most distinct in the posterior third, along the median line; this part of the ridge appears double in some shells, but in others there is only a single sharp ridge. On each side of this part of the ridges, but not extending its full length, are suboval scars of the adductor muscles. The central part of the shell is occupied by a large bilobed subcircular scar (? rather depression). The outer borders of these two depressions of the shell are defined by a sharp line, elevated in the middle of its length, and there bent toward the centre of the shell. The margin of the valve appears flattened and crenulated.

The dorsal valve is blunt and depressed at the umbo. Its disc smooth; except at the posterior end, where concealed in the blunt beak, is a short ridge, dividing the small scars of the (posterior) adductor muscles; a small scar on each side of the valve close to the edge, and about one

third from the beak, marks the attachment of the adjustor muscle. Opposite this there is a slight elevation or ridge on the median line.

*Sculpture.* This consists of concentric ridges and lines, and of less conspicuous radiating ridges.

*Size.* Length of ventral 4½ mm.; width 3½ mm. The dorsal valve is one half of a millimetre shorter than the ventral valve.

*Horizon and locality.* In a bed of fine gray shale, in the Dictyonema beds, Div. 3 *c.*, Navy island, St. John harbor, N.B.

Resembles a Lingulella.

Although in some respect resembling a Lingulella, there are in others such wide differences in this little shell that we have sought for relations in other genera, and notably to Obolella".

But as Obolella is now limited to thick calcareous shells, this species cannot find a place there, and our later studies have induced us to look to Hall's genus Leptobolus as the nearest approach to shells of this type.

The specimens from McLean brook, Cape Breton, are in better preservation than those of Navy island and show more clearly the characteristics of the species, the description of which is here reported.

Ventral valve. *Interior.* The cardinal area is from one sixth to one quarter of the length of the valve. "The suboval scars" in the posterior part of the shell are not now thought to be due to the adductor muscles which are smaller and further forward. There is a narrow median septum on some Cape Breton examples, extending from the umbo one third of the length of the valve. There are also lateral ridges diverging from the umbo; and, extending in an arch from the anterior end of those ridges, nearly parallel to the sides of the valve, are faint impressions of vascular trunks. The "large bilobed sub-circular scar" is the area within these trunks.

Dorsal valve. *Interior.*—There are faint impressions on the median line in the anterior part of the valve that mark the position of the anterior adductor muscles; those impressions are about one-third from the front of the valve. Extending back from this to the umbo is a sharp faintly defined mesian ridge. Lateral grooves or ridges extend out on each side from the umbo nearly as far forward as the mesian ridge.

*Sculpture.*—The better examples from Cape Breton show that this species had fine, well-marked concentric ridges; the radiating ridges belong to the surface of an inner layer of the shell.

At the time this species was described, its affinities were obscure, because in such small shells, the details are not readily observed unless the

mud in which they were preserved was very fine and had escaped alteration. This was not altogether the case at Navy island in St. John basin, but the medium of preservation at McLeod brook is in a more satisfactory condition, and hence we were able to see more readily points of resemblance to the genus Leptobolus.

Reasons for referring it to Leptobolus.

In Obolella the shell substance is calcareous and thick; in this there is a chitineous film, and the shell is quite thin. No very satisfactory impressions of vascular trunks were observed, but the position of the muscle scars and of the median ridge in both valves are most in accord with Leptobolus.

From Lingulella this species is distinct by the uniform thickness and tenuous substance of the valves. In Lingulella there is a thickening of the shell in the visceral cavity, while around the brachial cavity it is usually much thinner; in Leptobolus the shell-substance is thin and comparatively uniform except at the cardinal area of the ventral valve.

In the paragraph of the original description of this species, "In the general form," &c., the features described resemble the characters of Leptobolus as much as Obolella. or more so.

*Size.*—Length of ventral 4½ mm.; width 3½ mm. The dorsal va've is one-half millimetre shorter.

*Horizon and locality.*—Fine dark gray shale of Div. 3 c. at McLeod brook, Cape Breton, N.S.

By comparing the figures of the Navy island form with these, it may be gathered that the posterior cavity (scar) or depression of the ventral valve occupies the space of the visceral cavity, while the anterior depression is outlined by the vascular trunks. The ridge between these two depressions in the Navy island form might be compared to the cross-ridge in the shell of Leptobolus which Prof. Hall seemed to regard as of generic value.

### LEPTOBOLUS, cf. LINGULOIDES.

Leptobolus cf. linguloides.

A small linguloid shell is not rare in the fine shale of McLeod brook. As in others of this genus, the umbo of the ventral is weak and short, and so the two valves are not easily distinguishable. Owing to the thinness of the valves the internal features are only faintly indicated. The ventral shows two lateral ridges diverging from the umbo, and a callus is obscurely indicated; one example shows a trace of a vascular trunk on one side. The dorsal has an obscure medium septum extending to the middle of the valve.

*Sculpture.*—A very fine concentric striation is visible on some valves.

*Size.*—Usual length, 3 mm.; (largest, 3½ mm.); width 2¼ mm.; (largest, 2⅝ mm.)

*Horizon and locality.*—Gray shale of Assise C., 3 *c.*, at McLeod brook, Boisdale, N.S.

This species is nearly as large as *Lingulella linguloides* of the Lower Paradoxides beds near St. John, a species which we would also refer to Leptobolus. The outline also is similar, but the umbo of the ventral is weaker; this and the smaller size may be due to a more pelagic habitat.

LINGULEPIS STARRI, var. Pl. XIV., figs. 2 *a–c.*

*Lingulella gregwa* Walcott [non mihi] Proceed. U. S. Nat. Mus. Cambrian Brachiopoda, vol. xxiii, pages 669-695, [description without figures].

Variety of Lingulepis Starri—Mr. Walcott describes under L. gregwa.

The following is Mr. Walcott's description of this form under the name of *Lingulepis gregwa.* The diagnosis is arranged as nearly as possible, according to the plan followed in this report.

"General form elongate ovate, with the ventral valve acuminate and dorsal valve ovate triangular in outline. The outlines of the valves vary as shown by a series of specimens. The convexity of the valves varies with the conditions of preservation. Those from the sandstone are rather strongly convex, while in the shale they are very much compressed. On the dorsal valve of most young shells there is a marked and a rather broad shallow sinus, extending from the umbo to the front, where it flattens out.

*Interior.*—The plane of the cardinal area of the ventral valve is nearly coincident near its edges with the edge of the shell. The area is long and extends well forward on the cardinal slope. It is divided midway by a narrow, rounded, deep pedicle furrow, and about halfway between the pedicle furrow and the lateral margins, by an unusually well defined flexure line, which is in line with the main vascular furrows of the interior of the valves; fine striæ of growth cross the area, and arch around the pedicle furrow, parallel to the base of the area. There is practically no undercut beneath the area, except near the flexure line at the front margin of the area. The area of the dorsal valve is short and narrow, and crossed by fine lines of growth parallel to its base.

The cast of the visceral cavity in the ventral valve, shows it to have been relatively small, and usually confined to the posterior half of the shell. There is no trace of a median septum in the ventral valve; in the

dorsal valve a slightly elevated median line occurs at the bottom of the groove, between the central muscle scars, that extend forward to the anterior margin of the visceral cavity, beyond the anterior lateral muscle scars. The visceral cavity of the ventral valve extend forward to about the centre; in some shells it is back of the centre, and in others a little in front. It varies in width and outline very much as the shells vary, being wide in broad shells, and narrow in elongated forms.

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*Vascular system.*—The markings left on the shell by the vascular system are very strong, and beautifully preserved in some portions. In some shells there is a double groove with a slight ridge between; in others the ridge is large, only a trace of an outer groove remaining; in some young shells, the groove is broad and shallow; in all shells the large size of the main vessels is shown by the broad, strong grooves or ridges left on the shell. It frequently happens that the deeply indented lines of pits on the lines of growth deeply indent the grooves and rounded ridges, left by the main vessels, and mark them off into sections. The interior and lateral vessels left narrow but strong grooves or ridges on the shell, which however are usually obscured by the strong pitting of the surfaces.

The *parietal scar* surrounds the visceral cavity in each valve, crosses the course of the main vascular vessels, and comes back around the spaces occupied by the muscle scars, terminating at the edge of the area at the flexures in the ventral valve; termination unknown in the dorsal valve.

Some of the *muscle scars* are finely shown in the dorsal valve and fairly well in the ventral. The umbonal scar of the ventral valve is divided, the pedicle scar being situated between the two parts. In the dorsal valve the umbonal scar is close to the area, and extends nearly as far each side of the median line as the length of the area.

The scars of the central muscles in the ventral valve are crowded in with the middle and outside laterals within the trapezoidal space. In the dorsal valve, they are located on a low ridge each side of the central longitudinal depression; they are elongate oval in outline, their major axis being sub-parellel to the median line of the shell; fine longitudinal lines cross the scars in the best preserved specimens; the ridge on which the central scars occur varies in strength, but it appears to be present in all adult shells; it narrows gradually posteriorly and rather rapidly to the inner side of the anterior lateral muscles scars. The anterior laterals of the ventral valves, are placed well back on the narrow space between the edge of the area and the main vascular sinus; they are elongate and rather large; in the dorsal valve they are elongate, with the major axis inclined forward toward the median line. The middle and outer laterals are situated in the trapezoidal area of the ventral valve, but neither is

clearly separable from the other, or from the central scars. In the dorsal valve the position of the middle and outside laterals is shown, but not their form or size. The transmedian scars in the ventral valve are seen just back of the anterior laterals, but they have not been observed in the dorsal valve, owing to the imperfection of the shell.

*Sculpture.*—The surface of the shell is marked by concentric striæ, and undulations of growth, over which there is a series of very fine elevated, sharply undulating inosculating lines that form a minute, irregular network over the surface, very much like that of *O.* (*Lingulella*) *ella.* Where the lines are strongly elevated the effect is that of a minutely granulose surface. When the thin outer layer of the shell is exfoliated the surface of the various inner layers is minutely granulose in addition to the flattened, radiating striæ and concentric lines of growth. *Interior.* The interior surface of both valves is often marked by concentric lines of strong pits or punctæ, very much as in *O. Lingulella davisi.* In some specimens the lines of punctæ extend over the surface of the visceral cavity so as to obscure the vascular markings and muscle scars. In some examples only a few scattered punctæ occur, while in others they are present over nearly the entire surface. The small shells are thin, but the larger ones are built up of a very thin outer layer and several inner layers or lamella that are more or less oblique to the outer surface, especially over the anterior and lateral portions of the shell. Sculpture.

*Size.*—One of the largest ventral valves has a length of 21 mm., with a width of 18 mm. A dorsal valve 16 mm. in width has the same length; other example, are a litte wider than long.

*Formation and locality.*—Middle Cambrian. Upper Paradoxides beds, Siliceous shale and thin bedded sandstones west side of McLean brook, above Marion bridge, Salmon river. Gillis hill, 13 miles south of Marion bridge, Cape Breton island, Nova Scotia. [The locality on McLean brook in on the horizon C. 2 *b.* G. F. M.]

*Observations.*—This appears to be a representitive of *O. (L.) acuminatus* which is so abundant in the Middle Cambrian of the Upper Mississippi valley, and the passage beds between the Cambrian and Ordovician adjoining the Adirondack mountains of New York. It differs from that species in its greater average width and in its surface characters." Comparison with other species.

The above being the description of a shell from McLean brook, Mira river it is clearly not *L. Gregwa* which occurs at another locality and in lower terrane. A thousand feet in vertical thickness of sandstones, shales and flags separate the the two species and three distinct Cambrian faunas intervene. The "species" is really a variety of *Lingulepis Starri* of the

Johannian division of the St. John terrane. But as Mr. Walcott has obtained some excellent material of this species, showing it far better than the original material from St. John, I have adopted the above as a good description of the species. Some differences however may be noted.

I have found the visceral cavity of the ventral valve extended well into the anterior half of the shell, and that of the dorsal two thirds of the length of that valve.

The foundation of the ornamentation in this shell is a rough scabrous or granulated surface (with a tendency to develop anastomosing ridges as in Acrothele); toward the beak it seldom has other character, but at the middle and towards the front this surface is thrown into concentric ridges, not all regularly placed, but becoming more regular toward the front. Over the middle third these ridges are crossed by radiating ridges of nearly equal strength. On the middle of the valve there are about 7 to 9 of the concentric ridges in the space of 2 mm. In this they differ from the examples of the species from the St. John locality in which these ridges are much closer, and they are also more regular.

The arrangement of the muscle scars and form of the callus in this species is that of Lingulepis rather than of Lingulella. The great inequality of the length of the valves separates it widely from Obolus, in in which the cardinal area of the dorsal valve is high, and nearly equal to that of the ventral.

The back of the dorsal valve in this species seems to be subject to resorption; or else no growth takes place there, as the ends of the growth lines at the hinge are far separated from each other.

The following are dimensions of a few valves of this species.

DIMENSIONS OF VALVES OF LINGULEPIS STARRI FROM BAND C. 2. *b*.

| | Ventral. | | | | Dorsal. | | | |
|---|---|---|---|---|---|---|---|---|
| | No. | Length. | Width. | Depth. | No. | Length. | Width. | Depth. |
| Dimensions of the valves of L. Starri, var. | 1 | 19 | 17 | 2 | 1 | 13 | 5 | 2 |
| | 2 | 16 | 13 | 1½ | 2 | 12 | [illegible] | 2½ |
| | 3 | 15 | 13 | 2½ | 3 | 12 | 14 | 2 |
| | 4 | 15⅝ | 13 | 2 | 4 | [illegible] | [illegible] | [illegible] |
| | 5 | 15½ | 13 | 1½ | 5 | 11 | [illegible] | [illegible] |
| | | 81 | 69 | 10 | | 60 | [illegible] | 10 |
| Average | | 16·2 | 13·8 | 2·0 | | 12·0 | [illegible] | 2 |
| Proportion. | | 1·2 length to width. | | | | 0·9 [illegible] | | |

The ventral is about a fifth longer than wide, judging by these examples, and the dorsal a tenth wider than long.

This form was observed to have a raised median band on the inside of the dorsal valve which extended in one example four-fifths of the length of the valve. The median band in several examples was traversed by a narrow median groove, made double by a thread-like ridge in the middle; this groove was interrupted for a short space about one-quarter of the length of the valve from the hinge. Opposite this interruption, on each side of the thickened band or callus, are thinner oval areas of the valve which may be ovarian cavities.

Mut. EXIGUA, N. mut. Pl. XIV., figs. 3 *a–d.*

Mutation exigua from lower horizon described.

This form is smaller than that last described and shows much variability.

It is about one-third longer than wide; as preserved in the rock, is rather flat, and the shell substance is comparatively thin.

The *ventral* valve is ovate-acuminate, with sides straight for more than half of its length, then slowly and afterwards more rapidly rounded to the front. The usual proportion of length to width is 4 to 3, but others are more acuminate. Very often the umbo is mutilate, and sometimes the sides of the ventral toward the hinge-line are concave in outline. This valve is flattened toward the front, but more convex toward the beak.—*Interior.*—A decorticated example shows a callus extending to the anterior third of the valve, and the points of the lateral vascular ridges are still farther advanced; the vascular trunks just inside these ridges, curve inward toward the front of the valve.

The *dorsal* valve is ovate-cuneate and as long or longer than wide. It is arched down all round, and there is a depressed band along the middle, over the median septum. The *interior* shows a strong, broad median ridge or callus extending nearly to the front of the valve; the callus has a longitudinal groove. The lateral septa or vascular ridges are fainter, and between these and the median ridge, just at the cardinal line, are pits of the cardinal muscle.

*Sculpture.*—This consists of a rough, granulated surface, diversified with ridges concentric to the umbo; sometimes these ridges are distinctly visible from the umbo out; on other valves they are seen only from the middle of the valve forward, and are particularly plain and close together near the anterior margin. On the dorsal valve toward the umbo the ends

of these ridges are widely separated (owing to the resorption of the umbo?) and so appear more transverse there, than farther toward the front of the valve.

*Size.*—Ventral valve; length, 12½ mm. width, 9½ mm. depth, ½ mm.

*Horizon and locality.*—Slaty seams of the calciferous gray flags of Band C. 2 a. (also in Assise C. 2 b.) at McLean brook, Mira river, Cape Breton, N.S.

The folowing are dimensions of valves of this form.

VALVES OF LINGULEPIS STARRI, MUT. EXIGUA FROM BAND C. 2 *a*.

| VENTRALS. | | | | DORSALS. | | | |
|---|---|---|---|---|---|---|---|
| No. | Length. | Width. | Depth. | No. | Length. | Width. | Depth. |
| 1 | 12½ | 9½ | ½ | 1 | 9 | 8 | ½ |
| 2 | 11 | 7½ | ½ | 2 | 8½ | 8½ | ½ |
| 3 | 11 | 7 | ½ | 3 | 7½ | 7 | ½ |
| 4 | 9½ | 7½ | ½ | 4 | 6½ | 6½ | ½ |
| 5 | 10 | 6½ | ½ | 5 | 5 | 5 | ½ |
| | 54 | 38 | 2½ | ..... | 36½ | 35 | 2½ |
| Average... | 10.8 | 7.6 | .5 | ..... | 7.3 | 7. | .5 |
| Proportion. | 1.4 length to width. | | | ... .... | 1.04 length to width. | | |

The ventral is about two fifths longer than wide, and the length and width of the dorsal valve are about equal.

The acuminate beak of the ventral is usually broken off, otherwise the disparity in the length of the valves would be greater.

This form differs from *Lingulepis acuminata* of the Potsdam sandstone of the St. Lawrence valley (Beverly, Ont.) in the bluntness of the dorsal valve behind, and in the possession of a median sulcus; the valves of the Cape Breton form also have a scabrous surface. The ventral is flatter at the umbo and in both valves the muscle scars are in a more advanced position than they are in *L. acuminata*.

From *L. pinnaformis* of the St. Croix sandstone it differs in its rougher surface, less acuminate umbo, and in the advanced position of the central muscle scars.

From *L. cuneola* Whitfield it differs in its larger size, greater flatness, and more obtuse umbo of the dorsal valve. In form and size it is intermediate between *L. acuminata* and *L. cuneola*.

LINGULEPIS ROTUNDA. n. sp. Pl. XIV, figs. 4 *a–f.*

Minute, valves tumid; the ventral ovate-acuminate, the dorsal nearly orbicular. Lingulepis rotunda described.

Ventral valve rather bluntly pointed, and marked by undulating ridges of growth, irregularly spaced. *Interior.*—The hinge area is high and has a distinct pedicle groove, narrow deltidium and wide marginal area. The visceral callus extends half way of the length of the valve, and here the central group of muscles are placed. Divergent ridges on each side of the visceral cavity indicate the position of the lateral scars; and from these ridges extend forward, arching toward the front of the valve, faint impressions of the vascular trunks. The margin of the valve is flattened at the sides and in front.

The dorsal valve is nearly circular in outline and strongly arched; the slope is most abrupt toward the lateral margins, and the valve is somewhat flattened on the front slope. *Interior.*—No hinge area is apparent on this valve which is almost vertical at the cardinal line. Two small pits near the hinge are in the position of the lateral muscles; from here a broad medium septum extends nearly to the anterior third of the valve; on each side of this ridge are prints of the central muscles and at its extremity those of the anterior laterals. Lateral ridges more widely set, and less divergent than those of the ventral, separate the scars of the lateral muscles from the visceral cavity. In front of the lateral ridges are faint impressions of vascular trunks, that go somewhat directly toward the front margin. The edges of the valve at the sides and front are flattened.

*Sculpture.*—The outer surface of the ventral valve shows traces of growth ridges, but nothing of this sort was observed on the dorsal, which is covered with a minute tuberculation.

*Size.*—Length of the ventral, 4 mm.; width, 3 mm. The dorsal is 1 mm. shorter than the ventral.

*Horizon and locality.*—In gray flags of the middle division (Div. C, 2 *c*) on the eastern slope of the valley of McNeil brook (on the road to Trout brook) Mira river, Cape Breton, N.S. Resembles O. (L) rotundatus Walc.

This species appears to be near *O. (L.) rotundatus*, Walc.* but differs in its longer ventral valve and in the extremely narrow cardinal area to the dorsal valve.

*U. S. Nat. Mus. Proc. vol. xxi, p. 415,

LINGULELLA LÆVIS var. GRANDIS, n. var. Pl. xv, figs. 1 *a–d.*

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A large Lingulella of the form of the species described in Illustrations of the Fauna of the St. John Group* was found at Escasonie. Only ventral valves were obtained, and with one of them is here described an interesting ventral from the same horizon at St. John and which is thought to be of the same species. The valve from St. John shows what appears to be the pedicle, and its sinew within the shell.

valve.

Ventral valve broadly ovate with a bluntly pointed, rather high (but poorly preserved) cardinal area. The valve is thin and is evenly arched down in all directions from the centre. The details of the interior are somewhat obscured by the dorsal valve which was pressed down upon it. *Interior.*—A visceral callus, pointed in front, is outlined ; this shows the position of the cardinal muscles. The transmedian (*d*) and lateral muscles (*e*) are shown by faint scars and inside them, on each side of the valve a low ridge (*f*) extending forward nearly to the lateral margins ; at the extremity of these ridges is what appears to be the print of a muscle scar ; it is oval, is within the ridge and directed diagonally forward.

The sinew of the pedicle appears to be preserved in this specimen as a dark sinuous line, originating at a point (*k*) where in ventral valves of several species of this genus, a small scar has been observed, and extending out through the pedicle groove (*a*). From the beak of the shell it can be traced over the surface of the layer of shale on which the shell is preserved to the margin of the shale fragment containing the fossil. The sinew or muscle within the shell has a diameter of about $\frac{1}{4}$ mm. The pedicle itself outside of the beak of the shell, is considerably larger than the pedicle groove at the beak ; it is composed of at least three elements —a central thread of dissevered particles of black, shining, carbonaceous tissue ; this is perhaps a condensation of the coelon substance. It is encircled by a space showing but little organic matter ; external to this is a tube of strong black tissue, not shining like the central thread, but of compact and continuous substance ; external to this tube, there appear traces of organic matter which may be the remains of a fleshy and perishable covering. The diameter of the pedicle is about $\frac{3}{4}$ of a millimetre near the pedicle groove ; the part of the pedicle preserved is 3 mm. long.

alve.

The dorsal valve from Escasonie, like that above-described, is [illegible] both at the visceral callus and elsewhere ; it is most strongly arched in the posterior half, but flattened on the lateral slopes (this [illegible] may be due to pressure after entombment). The form is [illegible] but blunted at the umbo.

*Trans. Roy. Soc. Can. vol. ix, sec. iv, p. 39, pl. xii, fig. 4 *a–c*.

*Interior.* The cardinal area is high and has about seven furrows which are arched forward at the sides to the deltidial ridges (*b*); the areal borders (*a*) are thick and flattened. A small umbonal muscle-scar ? (*c*) is found just within the hinge-line; but at the sides of the area within the body cavity are stronger prints (*d*) which may be interpreted as paired cardinal scars or perhaps transmedian scars. The central muscles (*h*) are about two-fifths of the length of the valve from the back, and are rather close together; and the anterior laterals (*j*) are nearly as far forward as the mid length of the valve; a median septum (*i*) divides both pairs of muscle scars; there is a faintly marked median sinus (*m*) in the anterior third of the valve. The transmedian muscle scars (*g*) are small compared with those of most species of Lingulella and nearly as far forward as the centrals (*h*). Two small scars behind the transmedian appear to be those of the *l* and *k* laterals. Faint impressions of the vascular trunks (*k*) extend forward in a regular arch, rather near the margin of the valve.

The central scars in this valve are approximated as in Lingulella, not spread as in Obolus.

The surface of the callus shows abundant pitting as in *Lingulella Davisii* and other species of Lingulella and Lingulepis.

*Sculpture.* The surface of the valves is shining and smooth, except for shallow crescent-shaped grooves and more distinct growth lines; these are more distinct on the lateral and front margins than elsewhere. Besides these markings, a strong lens reveals a minute granulation all over the surface.

*Size.* Length of the ventral valve (from St. John), 21 mm.; width, 16 mm; length of the dorsal (from Escasonie), 17 mm.; width, 14 mm.

*Horizon and locality.* From layers of fine sandy shale of Div. 3*a*.

Compared with L. Davisii.

Salters' original figure of *L. Davisii* in the Memoirs of the Geological Survey of Great Britain, shows that that species like this one, was pitted over the visceral region,* and it is nearly of the size of these shells, but these do not exhibit the "satchel shape," supposed to be characteristic of that species, and which we find in the species next described from a higher horizon. (See page 203).

The position of the muscle marks in these valves may be compared with those of *L. Davisii* as figured by Mr. Walcott.†

VAR. LENS, Pl. XV, figs. 3*a-h*.

Lingula (?) lens Bull Nat. Hist. Soc. of N. B., vol. IV, page 274, pl. V, figs. 3 *a* to *h*.

*Mem. Geol. Surv. Great Britain, vol. 3, pl. 2 fig. 11 *a* and pl. 4, figs. 14 and 14 *a*.
†U.S. Nat. Mus. Proced. vol. XXI, pl. XXVII figs. 1 and 2.

**Shell substance calcareo-corneous. A broadly ovate form with rather thin, smooth valves, having flattened lateral slopes in the ventral valve, and being somewhat tumid toward the umbo in the dorsal valve.**

iption
. lens.

**Ventral valve rather blunt at the umbo, whence for about one-third of its length the curve of the margin is somewhat straightened; for the rest of the border it is regularly rounded to the front; the greatest width is a little in front of the mid-length. The umbonal ridge extends about half of the valve, whence to the hinge the sides of the valve are flattened; in front of the middle of the valve the slopes are evenly but flatly arched down to the margin.** *Interior.*—**The position of the central group of muscles is within the posterior third of the valve, and the position of the laterals is indicated by a bounding ridge; these features are very faintly marked.**

**The dorsal valve is broadly ovate, and its slopes are more strongly arched in the posterior half than elsewhere, otherwise it is like the ventral.** *Interior.*—**This has a sharp, low septum for half its length, and on each side a parallel ridge, extending to the middle of the valve; at half the length of these ridges are small lenticular scars, and at their outer ends the group of central muscles. The lateral muscles are opposite the middle of the median ridge.**

ure.

*Sculpture.*—**The outer crust in this species is normally smooth in appearance, but is beset with minute pits, and has a very minute concentric and radiating striation. The sculpturing of the layer beneath has impressed itself on the outer layer in different parts of the surface; at the sides and in front we find concentric ridges, and in the middle third the imprint of the vascular striæ that run toward the front margin. These markings are much more distinctly shown on the under layer.**

*Size.*—**Length of the ventral valve, 16 mm.; width, 13 mm. The dorsal valve is 1 mm. shorter than the ventral.**

*Horizon and locality.*—Thin calcareous layers in the flags of Div. 3*a* at McAdam shore, Escasonie, Cape Breton. The shell in these layers are freely intermingled with small lumps and particles of calcium phosphate. The phosphate lumps are frequently moulded on the shells, or entirely enclose them; though some shells are enclosed in the phosphate, others are free, and with fragmentary shells are mingled with the sand. Other masses of the phosphate are entirely free of the shells, and are smooth and shining, as though rolled on the beach; yet the flat, oval, or rod-like pieces of the phosphate seem the natural form which the substance assumed when in a gelatinous condition. Probably the formation of the phosphate was cotemporary with the entombment of the shells.

This shell differs from the type in the more obtuse and tumid umbo of the dorsal valve and the heavier and more prolonged umbo of the ventral valve.

### Lingulella, cf. Davisii, McCoy.

Lingulella cf. Davisii.

Examples of a Linguella which though smaller than the above species of the Lingula flags and Tremadoc slates of Britain, has the same general form, are found in the Asaphellus beds of Cape Breton. It has the nearly straight base and sub-parallel sides of McCoy's species. The dorsal valve has on the interior a median septum two-fifths of its length, and the whole interior, especially towards the umbo, is marked with scattered pits.

*Sculpture.*—Externally this shell has fine concentric ridges, which are crossed by very fine radiating striæ. The middle third is marked by numerous, fine, radiating, vascular lines, and the lateral borders are flattened at the sides.

*Size.*—Length, 10½ mm.; width, 9 mm. Infrequent.

*Horizon and locality.*—In the gray shale of Assise C. 3 $c^2$, at McLeod brook, Boisdale, N.S.

### Lingulella concinna, Pl. XIV, figs. 5*a*–*b*.

*Lingulella concinna*, n. sp. Bull. Nat. Hist. Soc. of N. B., vol. iv p. 273 pl. v, figs. 2 *a* and *b*.

Lingullela concinna described.

Occurring in the dark gray shales of the Upper Cambrian on McLeod brook are a few examples of a small Lingulella, smoother than the species from the same beds referred provisionally to *L. lepis*, but ornamented, as that species is, by concentric ridges.

The shell substance is quite thin towards the lateral and front margins, and is there flattened out by pressure. The beak is somewhat blunt, and the rounded lateral margins give the ventral valve an ovate form.

*Sculpture.*—Over the visceral space the surface of the valves is covered with very fine concentric somewhat lamellose ridges, visible with a lens; over the branchial area these ridges flatten down, and the valve has a shining granular surface; the ridges, however, remain distinct on the lateral margins, though there also the surface is bright.

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* Introduction to study of Brachiopoda, Hall & Clarke. p. 229; fig. 23, and pl. 2, fig. 5.

† U. S. Nat. Mus. Proc. vol. XXI, p. 385. Pl. xxvi; fig. 1.

‡ Imp. Acad. des Sci., St. Petersburg. Ser. VIII, Tom. iv, No. 2. Pl. II, figs. 19c and 21c.

*Size.*—Length of the ventral valve, 8 mm.; width, 6 mm. The dorsal valve is nearly 1 mm. shorter than the ventral.

*Horizon and locality.*—In the fine dark gray shales of Div. 3*c*, at McLeod brook, Boisdale, N.S. Scarce.

ıe same (L) ɔtt.

Mr. Walcott has referred this species to his *O.* (*L.*) *bellus** which was published without figures. I may say, however, that I have compared it with Walcott's species, and find that it is smaller, has finer growth lines, and they are more sharply defined on the surface.

### Lingulella, cf. L. lepis, Salter.

cf. *Lingulella lepis* Salt. mem. Geol. Surv. Great Britain, vol. iii, p. 538, fig. 11.

lella ıis.

A species which by its size and sculpture appears to agree with this, is common in the Dictyonema shales both in Cape Breton and in southern New Brunswick; it is also found in the beds below this horizon, for in the assises 3*a* and 3*b* in the St. John basin, are many examples of similar shells, but they are so distorted and flattened as to be unrecognizable.

### Lingulella radula, var. aspera n. var. Pl. XV, figs. 2 *a* to *d*.

lella -aspera ption of.

Mingled with the shells of *L. radula* in the flags of Div. 2*c* at Courtney bay, St. John, N.B., are the valves of a smaller species, which in the description of the fossils from that locality was spoken of as a variety of that species.† It appears to agree in form, size and markings with a small species from the flags of Mira river, Cape Breton, which is here described.

A small ovate species, ventral rather flat, dorsal tumid.

The ventral has an acute projecting beak, but elsewhere the relief is flattened, and gently sloped to the margin. *Interior.* An example partly exfoliated shows a strong pedicle groove and rather high area. The cast of the interior exhibits a thickened visceral callus extending less than half of the length of the valve, with impressions of the central muscles about two fifths of the length of the shell from the apex. Faint imprint of the vascular trunks are traceable, extending to [illegible] of the length of the valve from the front.

The dorsal valve is strongly convex, and has flattened [illegible] on the under side. *Interior.* The cardinal area is rather high, [illegible]

* Proc. U. S. Nat. Mus., vol. xviii, p. 685.

† Trans. Roy. Soc. Can., vol. viii, sec. iv, p. 148.

twelfth of the length of the valve. The central group of muscle scars is rather large and lies at the bottom of the deep cavity of the valve; the anterior laterals (j) are a little more than a third from the front of the valve. Distinct impressions of vascular trunks may be seen on each side toward the margin of the valves.

*Sculpture.*—The outer surface appears dull and without lustre, but in proportion to the size of the shell, it is coarsely granulated, and towards the margins has indistinct ridges parallel thereto.

*Size.*—Length of the ventral 5 mm.; width 4 mm. The dorsal is ½ mm. shorter.

*Horizon and locality.*—Collected by M. A. H. Foord on the Mira river in 1874. The special locality is not given, but the matrix is a fine micaceous sandstone like the flags of Div. C. 2 *c*.

Compared to other species.

The resembling form mentioned above as occurring in the St. John flags at Courtney bay is somewhat smaller but has a similar radular ornamentation.

This species is nearly as large as that described by Mr. Walcott as *O (L) bellulus* from Kellys island, Conception bay, Newfoundland.*

This latter species is the same as that described by Dr. Whiteaves many years ago from that locality under the name of *Lingula Billingsana*. I have co-types of this species and of *L. bellulus*, butI do not find on the Cape Breton species described above the fine irregular striæ said to be characteristic of the latter. It is also a comparatively wider species.

## WESTONIA, subgen. Walcott.

Sub-genus Westonia of Walcott.

"Ovate, with ventral valve slightly accuminate; area of ventral valve strongly defined, and divided by a relatively large pedicle groove. Surface marked by concentric and radiating striæ that are crossed by transverse semi-imbricating ripple-embossed lines. As far as known, the muscle scars and vascular markings are essentially the same as in Obolus."

Mr. Walcott takes for the type of this subgenus *O. aurora* of the St. Croix sandstone (upper part) and with this, his diagnosis agrees. And he includes *Lingulella (?) lens* of the Cape Breton fauna, with which the description of the subgenus does not agree in several respects, *e.g.* the ventral valve is not acuminate but is bluntly pointed, the area though well defined, is not high, being about one seventh of the length; and

* Proc. U.S. Nat. Mus. vol. xxi, p. 398 (no figure). Am. Jour. Sci. 3 Ser. xvi, '78, p. 226.

the transverse ridges are not imbricated, but smoothly rounded. The character of the hinge of the dorsal of *L. Escasoni* is quite different from Obolus. The area is quite low and the posterior end of the valve rounded steeply down; whereas in Obolus the area is high and that end of the valve flat.

Also in the ventral valve the scar of the central muscles is triangular as in Lingulella, not rounded in at the sides as in Obolus. For these reasons, if *L.* (*?*) *Escasoni* is to be included in Westonia, to me the subgenus would seem to be related to Lingulella rather than to Obolus.

The ornamentation of peculiar transverse waving ridges, however, is a convenient common character that unites a number of forms and so is useful as a feature held in common, and due to a like origin, in these beautifully ornamented shells.

The Canadian species being of the Peltura Zone is a little older than O. (L.) *aurora*, which being associated with *Dicellocephalus Minnesotensis* should be within the Tremadoc Zone.

### Westonia Escasoni. Pl. XVI., figs. 1 *a-h*.

Nat. Hist. Soc. of N. B. Bull. vol. iv, p. 270, pl. v, figs 1 *a-c* Matt.

a
i
d—
valve.

"Corneous, but having a thin outer calcareous layer. The inside of the edges of the valves is flattened.

*Ventral valve* ovate, pointed at the apex, somewhat elevated from the umbo, along the axial line. *Interior.*—Cardinal area short, traversed by a depressed pedicle groove. The cavity between the umbo has impressions of two small, cardinal muscles, from which radiate two grooves,
tral bordered outside by ridges that separate the lateral muscle scars from the visceral cavity. The print of the central muscle is oval or lenticular and transverse to the axis of the valve; it is divided lengthwise, half way, by a septum; the posterior half of the scar is again divided by a faint ridge at right angles to the septum named. The "l" laterals are small triangular imprints in front of the outer part of the central muscles. In some valves the paired scars of the "k" laterals at the middle of the central group are small, and behind them extending toward the umbo is a sharp furrow enclosed between narrow ridges; in others they are wider and the ridges are not preserved. The grooves of the lateral muscles are discernable near the hinge on each side; the transmedian ("i") being external and on the inner edge of the flattened margin of the valve; the ("j") laterals are on the slope of the valve within the flattened margin.

The vascular trunks extend forward in a regular arch from the middle of the valve a little within the flattened margin, which is creased transversely by about a score of closely set parallel grooves. In the anterior third these give place to grooves that are at right angles to the margin; these correspond in course to the faintly impressed sub-parallel grooves that extend from the front margin across the middle of the valve to the visceral callus. Faint traces of branches of the vascular trunks are seen on the slopes of the valves in the anterior half.

The *dorsal valve* is of an oval form. It is strongly arched down in the posterior half, but less so on the anterior slopes. *Interior.*—This shows at the cardinal lines a depression in which are a pair of circular pits, due to the cardinal muscles. Between these pits, on the axial line, is a small pit from which two sharp low ridges run forward; at one-third from the back of the valve there is a minute scar between these ridges; and outside of them in the posterior half of the valve are the large oval prints of the central ("h") muscles; these are set somewhat diagonally to the axial line, having the fronts turned outward. At the anterior ends of the median ridges are the small scars of the anterior lateral ("j") muscles. Faint diverging ridges extend from the umbonal cavity toward the lateral margins of the valves; at one-third from the back, partly on and partly outside the ridges are the large but rather faint imprints of the posterior lateral muscles. Dorsal valve.

This valve, like the ventral, has flattened margins on which are imprinted minute, closely set, transverse grooves.

*Sculpture.*—The sculpture of the true outer surface of this species is not easily found; it is imprinted on a thin calcareous, fibrous layer, which is usually broken away, revealing the next layer of the shell. The outer layer is crossed transversely by closely set striæ, forming ridges, of which there are about nine or ten in the space of a millimetre; some of these ridges have cross striæ at intervals; others anastomose, and all have a roughened surface; the ridges have a waving course over the middle third of the shell, but elsewhere are comparatively straight. Sculpture.

Beneath the outer shell is a corneous layer whose sculpturing conforms to that of the outer layer, but the striæ are wider and the intervening ridges narrowed; this layer has a shining surface. Beneath this is a third layer on which the striæ run in an opposite direction from those of the one above, the sculpturing, especially along the central part of the valve, consisting of striæ radiating from the umbonal region to the front margin; these are crossed at intervals by undulations of growth concentric to the umbo; on the inside of this layer are impressed the surface markings of the interior of the valves.

*Size.*—Length, 5 to 5½ mm.; breadth 4 to 5 mm.; depth of each valve about 1 mm. The ventral is about ½ mm. longer than the dorsal. One dorsal has a length of 6 mm.

*Horizon and locality.*—In calcareous sandy layers with the Peltura fauna (C. 3 *b*.) at McAdam shore, Escasonie, Cape Breton. This species was not found *in situ*, but in loose pieces of thin flag in the shingle of the shore where the trilobites occur: these pieces were very little worn, and therefore near or at the parent ledge. This species may be referred to the Peltura Zone, (C. 3*b*).

Compared with other species.

This species is referred doubtfully to Lingulella as it has some characters of other genera. The weak cardinal development is like Leptobolus; as is the long lateral ridges and advanced ("j") laterals of the dorsal valve. The spreading vascular trunks of the ventral valve are like Leptobolus and Obolus, as also the advanced "j" lateral. On the other hand the thick shell is quite unlike Leptobolus, but common in Obolus and Lingulella.

This pretty little species is easily recognized by its peculiar transverse sculpture. *Lingula tæniola*, Hall, has a similar transverse ornamentation, but is much larger, and flourished at a later period (Clinton group).*

*Lingulella Ella*, H. and W., has a somewhat similar sculpture, but is distinguished by its greater size and closer approximation of the vascular trunks of the ventral valve.

It is only in a few valves out of many that we find distinct muscle scars, enabling us to compare the species with others. Michwitz has determined that the exterior half of the central muscle in the ventral valve of Obolus represents the "l" lateral of Lingula.† In this relation it is interesting to observe that the great muscle in L. (?) *Escasoni* also has a septum partly dividing it; but there is a separate scar, a small triangular one, at the anterior outer angle of the great muscle, which with more probability may be considered the external lateral or "i" muscle; the large oval muscle would then be the "h" central (with possibly the "k" lateral involved), but it would consist of three main strands; for beside the septum across the middle at the back, the scar is divided by a more obscure transverse ridge parallel to the long diameter of the scar. This muscle then may be compared to those of Lingula, etc., having divisional lines.‡

* New York State Geologists' Report. Hall & Clarke, 1891, pl. I, [illegible].

† Mem. Acad. Imp. des Sci. St. Petersburg. Series VIII. Tom. [illegible] 79

‡ Introduction to study of Brachiopoda, Hall & Clarke, p. 229; [illegible]

In *O. (L.) cælatus*, Volb., we see an arrangement of muscle scars in the central group of the ventral valves similar to that in *L.* (?) *Escasoni.** Here Mr. Walcott interprets the small scar as an external lateral ("l"), but the larger one as a middle lateral ("k"). Volborth's figure of this species does not show the small scar, but he appears to allude to it in the text where he says that "the several laterals of the ventral valve are not so closely bound together as in the subgenus Euobolus.†"

## LINNARSSONIA, Walc.

### Obolus.

An orbicular brachiopod (a single valve) was found in the flags of Div. (C. 2*b*.) on the east side of the Long Island passage. The material is not sufficient to determine the species. An Obolus.

### Linnarssonia, cf. Belti, Davidson? Pl. XVI. figs. 3*a-c*.

*Linnarssonia Belti*, Dav.? Trans. Roy. Soc. Can. vol. ix, p. 42, pl. xii figs. 7*a-c*.

The shell of the St. John Basin referred to this species, has the following characters :—

Shell oblately orbicular. Test corneous.

The dorsal valve (?) resembles that of the shell (*O. misera ?*) in the zone (C. 1*d*) of the St. John Group, being like that of an Acrotreta in its internal markings. Linnarssonia cf. Belti.

In the ventral valve we do not see the strong scars and V-shaped ridge at the umbo, of the typical forms of Linnarssonia, but in their place small scars, and two faint V-shaped lines extending from the umbo.

*Sculpture.*—The surface of the shell is marked with fine concentric and less distinct radiating lines, or is smooth.

*Size.*—Length 3 mm.; width 3½ mm.

*Horizon and locality.*—From fine gray shales of the Dictyonema beds (Div. C. 3*c*) at Navy island, St. John harbour.

This little shell is distinguished from those that occur with it (except Acrotreta), not only by its form, but also by the extreme tenuity of its test, thickened only at the umbo. In this also it resembles the shell from Div. (C. 1*d*) referred to above, and those of the genus Acrotreta.

* U. S. Nat. Mus. Proc. Vol. XXI., p. 385, Pl. xxvi., fig. 1.

† Imp. Acad. des. Sci., St. Petersbourg. Ser. VIII., Tom. iv., No. 2. Pl. II., figs. 19*c* and 21*c*.

ling This shell is referred provisionally to *Obolella Belti*, Dav., of the Lower Tremadoc in North Wales, which is about the horizon of our species. Davidson remarked that the "internal characters agree pretty closely with those of *O. sagittalis*." On comparing Davidson's figures of the ventral valves of *O. Belti* and *O. sagittalis*, one may remark differences similar to those which distinguish *O. (L.) misera*, Bill. from *O. (L) transversa*, Hartt, of the St. John Group. In *O. Belti* and *O. misera* the muscle scars are fainter and nearer the back of the shell, and the umbonal callus is smaller than in the other two.

This species is not common at McLeod brook. The V-shaped ridge of the ventral valve runs about half way to the front, and is more U-shaped than with the other species.

The ventral valve has a strongly marked median ridge in the middle third of the length of the valve, in front of this the ridge extends as a low elevation nearly to the front margin. Opposite the high part of the ridge, in the posterior third of the valve, are two strong triangular pits which appear to be muscle scars. The posterior lateral margins of the valve are flattened.

*Sculpture.*—Often the surface is finely granular, and the dorsal shows a few concentric ridges of growth.

*Size*, as stated above.

*Horizon and locality.*—Fine dark grey shales of Div. (C. 3c,) at McLeod brook, Boisdale, Cape Breton.

N.B.—Mr. Walcott, who has examined the examples from Navy island says they are not *L. Belti*, Dav.

## MONOBOLINA, Salter, 1865.

### MONOBOLINA REFULGENS.

Pl. XVI. figs. 2*a-b*, also Pl. XI. figs. 1*c* and 1*e*.

*Obolus refulgens*, Matt. Trans. Roy. Soc. Can. vol. ix sec. iv page 14. pl. xii. figs. 6*a-d*.

olina Since the description of this species was written, in 1890, no observa-
as. tions had been made which would define more accurately the internal characters of this shell, or throw additional light on its affinities. The more perfectly preserved shells collected lately in Cape Breton, however, have changed the writer's view of the relation of this species.

A sharply preserved mould of the dorsal valve shows that the species is congeneric with *Obolella (Monobolina) plumbea* of the Welsh Lower Ordovician, characterized by the close approximation of the central

muscles of the dorsal valve. In Obolus, sens. strict., these muscles are well apart.

The following is the original description of this species :—

Shell oblately orbicular, lenticular, edges thin, sharp, flat. Test corneous, surface brilliant.

Description of the valves

The ventral valve is produced at the back into a low, rather blunt beak, depressed at the point. In the *interior* of the ventral valve, there are at the back three ridges, which diverge from the umbo; of these the mesian ridge dividing the posterior adductor muscles, is short and weak; it is forked at the end (where it terminates against the scar of the pedicle muscle?) The two lateral ridges are longer, being about one-quarter of the length of the shell, and are more distinctly outlined, by a long narrow pit on the inner side. The visceral cavity is wide in front and terminates in a long sinus; some specimens show in this sinus a muscular callosity. The hinge area is narrow, and deflected downward in the middle. It is crossed by a shallow pedicle groove.

The dorsal valve has at the hinge a very thin edge, turned inward. The *interior* is marked by three diverging ridges, of which the central is longer than the lateral ones. The central ridge when well preserved, appears to extend two-thirds of the length of the shell, and is distinct as far as the middle of the shell, where there are two small muscular impressions; at the back of the shell, between the mesian and lateral ridges, are the impressions of the [posterior] adductor muscles. There is a large shallow bilobed depression in the anterior half of the shell. The cardinal border is thin and is made much more distinct by a pair of small narrow transverse pits, one on each side of the mesian ridge.

*Sculpture* (1).—The surface is marked by very fine concentric and radiating lines, and there are stronger concentric growth lines at intervals on the surface.

*Size.*—Length of the ventral valve 8½ mm.; width 10 mm. The dorsal valve is half a milimetre shorter than the ventral.

*Horizon and locality.*—In the Dictyonema shales (Div. C. 3c) Navy island, St. John harbour.

No very satisfactory examples of the marking of the interior of the valves were found, in any one individual; but by combining the markings found on several valves of the dorsal and ventral sides respectively, it has been found possible to restore some of the features of the interior of the shell."

There is little to add to the description of the ventral valve, but the small size of the space occupied by the muscles is remarkable. The height of the cardinal area is only about one-eight of the length of the valves, which is not the case in Obolus.

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rior.

A mould of the interior of the dorsal valve from McLeod brook, shows much more distinctly than those from the St. John basin the nature of the impressions of the central muscles; and the crowding together of these scars, corresponding to the description of Monobolina by Salter. Although there is sometimes a faint elevation on the median line in the anterior of the valve, the median ridge cannot be said to extend beyond the mid-length of the valve, and it is bordered by two deep and narrow grooves in the anterior half of its length, that separate the print of the anterior adductors, which in their turn are bordered outside by a shallow groove, as represented by Davidson for *Monobolina plumbea*. The posterior half of the mesian ridge is much fainter than the anterior; in fact the posterior half of it is almost obsolete.

The position of the central group of muscles in the dorsal valve of this species (*M. refulgens*) as well as the short visceral callus of the ventral valve, appear to exclude this species from Obolus, and show its neareness to, or identity with Monobolina. Moreover, the weak muscle scars, and the absence of an area to the dorsal valve, are also not found in Obolus.

s of
ace.

*Sculpture* (2).—The state of preservation of the examples from Cape Breton, give a much better knowledge of the surface characters of this species, than those from Navy island. The surface was spoken of as "brilliant", but this brilliancy is found on the second layer of the shell; the Cape Breton examples appear to have a thin outer prismatic layer of mineral matter, which (if not an accidental addition) is a dull surfaced outer layer, which when viewed with a strong lens exhibits a finely granular surface, ornamented with concentric ridges; these ridges are low, often interrupted or broken, and separated by smooth granulated spaces. The under corneous layer is also marked by concentric undulations of growth, and towards the front of the shell, and especially on the inner surface of this layer, by numerous sub-parallel lines, radiating from the umbo. There is still another layer of the shell which forms its inner surface, and on which the muscle scars and vascular trunks are impressed.

I more than suspect that the surface which Mr. Salter described as that of *Obolella (Monobolina) plumbea* is the corneous surface of that species, corresponding to the similar one in this.*

* Mem. Geol. Surv., G. Britain, vol. iii, p. 539, London, 1881.

*Size.*—Length of the ventral (of *M. refulgens*) 9½ mm.; width, 11 mm.; length of dorsal nearly 9 mm.

*Horizon and locality.*—In the fine dark gray shales of Band C. 3 *c.*, at McLeod brook, Boisdale, N.S. Common.

Compared with M. plumbea.

Comparing the species with *M. plumbea*, there is a considerable difference in size, Salter's figures being of the natural size. Davidson's figures show a shell about as large as the largest of *M. refulgens*. The proportion of the outline of the valves given by Salter of 3 to 4 are different from our species in which the proportion is about 5 to 6; the Cambrian species therefore is rounder than the Ordovician. But Davidson's figure has nearly the same proportion as the Cape Breton form. In Salter's species the cardinal area of the ventral valve is higher, and the visceral cavity proportionately larger than in this species.

Salter records a variety of *M. plumbea* (*plicata*, Hicks) as occurring in the Tremadoc group,* which would come almost within the range of *M. refulgens*; and forms like the latter have been seen as low down as the Assise *a* of Division 3 of the St. John Terrane.

## ORTHIS.

ORTHIS LENTICULARIS, Dalman, Pl. XVII, figs. 1 *a–d.*

1821. *Atrypa lenticularis* Wahl., Petr. Tell. Suec., p. 66.
1827. *Atrypa lenticularis* Dalm., Vet. Acad. Handl. p. 132; Hist. Leth. Suec., p. 76.
1834. *Spirifer? lenticularis* L. von. Buch., Abhandl. d. Berl. Acad. p. 48 Tab. i, figs. 13–14.
1857. } *Atrypa lenticularis.* Kjerulf., Geol. d. Südl. Norw. p. 284.; Vei-
1865. } viser &c. p. 1–3, fig. 7.
1866. *Orthis lenticularis* Dav., Geo. Mag. vol. v. tab. xvi, figs. 20–22.
1871. *Orthis lenticularis* Dav., Brit. Silur, Brach. p. 230, tab. xxxiii, figs. 22–28.
1891. *Orthis lenticularis.* Wahl., Trans. Roy. Soc. Can. vol. ix, sec. iv, p. 48, pl. xii, figs. 9 *a–d.*

Orthis lenticularis.

The following is Wahlenberg's original description of this species:—

Suborbicular, on each side a little convex, radially undulate. In a "suillous" rock [fetid limestone] in beds of aluminiferous slate, in which material no other shell has been found. It occurs plentifully everywhere throughout several provinces. In size and in its situation resembles at first sight the pea-shaped entomostracan [*Agnostus pisiformis*]

* Mem. Geol. Surv., G. Britain, vol. iii, pp. 355, 368.

which occurs in the same rock. Each valve possesses an equal convexity, so that when united they very much resemble the seed of a lentile. The valves are seen to have been very thin in their substance.

Dalman's description is fuller, and is as follows :—"A small species with very slender and fragile valves. Length about 4 mm., and of about the same, or somewhat greater breadth. An entire specimen is rarely found, but the species is very easily distinguished on account of the stone in which it occurs, as it has scarcely any other species of Terebratulite with it. The shell is suborbicular, with the base somewhat prominent, and a little convex; toward the margin it is sensibly compressed. Striæ of undulating lines, in number about twenty, but indefinite. Without a yoke (deltidium) or canal to the dorsal (ventral) valve. In the complete state no transverse furrows have been observed, but deprived of the epidermis (outer shelly layer) the radiating striæ are wanting, and the shell appears concentrically striulate. The true structure of the hinge is not rightly explored, but, on account of the external aspect, and its place in the most ancient strata, the species is suspected to belong to the genus *Atrypa*."

Leopold von Buch, in the work above cited, presents us with another view of this species, and from his impressions of its form and relations referred it doubtfully to the genus *Spirifer*. His account is as follows :—

"Both shells are slightly elevated; both, however, have a slightly depressed (hollow?) in the middle opposite each other. The margin it square-oval, with sides sloping away, and slightly bent down at the back. The hinge of the ventral (dorsal) shell is straight; in the dorsal (ventral) valve on the contrary, the edges of the hinge are bent into a very blunt angle. This is the only way by which one can distinguish the valves from each other, for the area, which in itself is very small, lies always on the under edge. The greatest width is in the middle of the length (transverse diameter). From 8 to 10 radiating lines go from the middle point (umbo) out, and increase at the border to form 18 to 20 lines. Very fine crowded lines of growth cross these and form a very pretty pattern. Length to the width as 100 to 131.

This little mussel is crowded together in enormous numbers. They build alone the alum-shales of Andrarum in Schona. Indeed, Dalman says that such beds occur throughout the whole of West Gottland, and also in several other provinces of Sweden."

Of this species Salter gives the following description referring it to the genus *Orthis* :—

*Wahlenberg Petr. Tell. Suec. p. 66.

"A well marked and very pretty species, and the earliest known in British rocks. It is hardly ever more than one third of an inch wide, and most specimens are not more than half of that size. The length is less than the breadth in proportion as seven to nine. Our figures represent the shell as distorted in various positions, but the above is about the average measurement. Both valves are somewhat convex, but the dorsal valve has a broad central depression of a triangular shape, bounded by two rather prominent ribs, out of the ten or twelve strong ones that radiate from the beak, and the sinus is occupied by two sub-central and very distinct ones. The lateral ribs are strongly interlined by others half way up, the intervening ribs becoming as strong as the primary ones, and these again by smaller and shorter ones in the intervals. All are crossed by strong, and interrupted, but rather wavy ridges of growth, so as to decussate the surface in rather a remarkable way. The other valve is alike in sculpture, but has a rather prominent beak. The number of ribs varies greatly, but not in a way to make us believe we have more than one species. Sufficient differences are not seen in the Scandinavian specimens to warrant us in separating these which occur in abundance in the alum slates in limestone layers. Salter's description.

The teeth diverge slightly in both valves; in the dorsal valve they are subparallel, and short, or even curved a little inward, and are not thickened; while the cardinal process between them is a mere line or thin edge, which extends as far down as the length of the short lateral teeth, but is often very obscure, and sometimes seems to be altogether absent.

There is little doubt that this is Dalman's species from Egeberg, though the specimens we have from thence have less prominent ribs, and a generally smoother appearance."

If the reader will compare together these several descriptions of this species by the above writers, he will be surprised at the diversity they exhibit. This diversity, it appears to the writer, is due partly to the imperfection of the descriptions of the early writers, but chiefly to the remarkable variability of the species.

Wahlenberg takes no notice of the difference between the dorsal and ventral valves, for he ascribes to them an equal convexity, and say that the two valves occur together; but Dr Lindström intimates that they have never been found united, and from specimens which he has kindly sent me, it is clear that the Swedish variety has the usual sulcus in the dorsal valve, though in some cases only faintly marked. In the typical form of this species the cardinal area is short and the beak quite low; and as the convexity of the two valves does not differ greatly, this appears to be the form which Wahlenberg had in view when describing the species.

Dalman's description on the other hand, applies best to a variety *atrypoides*. He, like Wahlenberg, appears to describe only the ventral valve.

Leopold von Buch, while recognizing the distinctness of the two valves, ascribes a sulcus to the ventral valve which apparently has not been observed by any other writer. With this exception, his description applies to the type of the species; that is, the evenly lenticular form with a short hinge line. The extreme thinness of the shell fully bears out Dalman's remarks on this point, and is associated with inconspicuous hinge teeth and dental plates. The internal markings of the shell produced by the attachment of the muscles and the ovarian spaces are only faintly indicated and often quite undiscernable.

re of ace. *Sculpture.*—There is a wide variation in this respect in examples of different ages, and in the different varieties. As a rule the young shells, especially the ventral valves, are smooth, with only slightly marked diverging ridges. In the Acadian examples of this species the sculpturing is always more distinct on the dorsal than on the ventral valve; this I find is also the case in the Swedish examples, for which I am indebted to Dr Lindström. As the shells grew larger the ribs became more distinct; and also more numerous by the intercalation of new ribs towards the margin. L. von Buch gives 18 to 20 as the full number of ribs in the adult. This is the usual number in the St. John examples, though a few show as many as 30 ribs.

*Size.*—The largest example of this species observed at St. John is 8 mm. long and 11 broad; but Brögger mentions that an example from Vestfossen was 15·5 x 12·5. Dr Lindström has not seen any so large. A medium sized shell of 5 x 6 mm. is by far the most common in rocks of Eastern Canada.

*Horizon and Locality.*—This species is found in limestone lentiles enclosed in the black shales of Division C. 3 *a* at Germain street, St. John (also in similar shales of C. 3 *b*, on King Street, and elsewhere) occurring together as in Sweden, in great numbers and of all sizes.

I have not observed the Cape Breton examples to vary from the above descriptions. In that island the fossil has been found at the localities named below.

*Horizon and locality.*—At McNeil brook, east of Mira river in Band C. 3 *b*; at Gillis Brook, on East Bay and at McLeod brook, Boisdale, probably in the same assise, though possibly in Assise C. 3 *c*.

VARIETIES. Pl. XVII., figs. 2 *a-c*, 3 *a* and *b* and 4 *a* and *b*.

es. Among the forms found at St. John are three which also may be looked for in Cape Breton, viz.: *lyncioides*, with strong radiating ribs, especially

in the later larval stages; *atrypoides*, narrow with prominent umbo to the ventral and deep sulcus to the dorsal valve; and *strophomenoides*, with flat, smooth valves and long hinge-line. The two first mentioned forms are from the Peltura fauna (C. 3*b*), and the last from the Parabolina Zone (C. 3*a*).

## MOLLUSCA.

### Modiolopsis (?) cf. M. Solvensis, Hicks.

Bull. Nat. Hist. Soc. of N. Brunswick, vol. iv., p. 408.

Modiolopsis cf. Solvensis.

Long-ovate, elevated toward the umbo and carrying its fullness towards the lower posterior end of the valves.

The umbo is near the anterior end, and there is a small, transversely elongated scar just in front of it.

*Sculpture.*—The bad condition of the fossils leaves this doubtful for most of the surface, but there are faint concentric striations toward the lower margin and the posterior end. Only two examples known.

*Size.*—Length 4½ mm.; width 2½ mm.

*Horizon and locality.*—In the fine gray shale of Assise C. 3 $c^2$ at McLeod brook, Boisdale, N.S.

This species resembles that above cited of Hicks, but lacks the strong ridge extending backward from the umbo. It is also only half of its length.

## BELLEROPHON, Montf.

### Bellerophon insulæ. Pl. XVIII, fig. 3.

Bull. Nat. Hist., Soc., of N. Brunswick, p. 408, pl. xviii, fig. 3.

Bellerophon insulæ.

A small thin species, having about three whorls, of which the outer is enlarged and more than twice the height of the others; it is emarginate on the ventral side, and shows no keel; it has from two to three concentric growth ridges in the outer half of the last whorl.

*Sculpture.*—The outer whorl shows a very fine concentric striation, visible only with a strong lens.

*Size.*—Height across the whorls, 7 mm.; width across the shell from the emargination of the aperture at the ventral side, to the dorsum opposite, 4 mm.; width across the aperture from ventral to dorsal, 4½ mm.

*Horizon and locality.*—In the gray shale of Assise C. 3 $c^2$ at McLeod brook, Boisdale, N.S.

Dr. Henry Hicks' species (*B. Ramsayensis*), which is about the size of this one, may be con-specific with it, but the Welsh specimens are too

much distorted to be used for satisfactory comparison, and his description is brief.*

Prof. W. C. Brögger figures a species (*Bellerophon Norvegicus*), from a corresponding horizon in Norway.† It is a little smaller, the outer whorl expands more rapidly and is free for half of its length; it is not deeply notched like our species; though differing in these respects, it has a striation similar to the Canadian species, only in place of being sharply curved back at the dorsum, the striæ curve forward in crossing that line.

BELLEROPHON BRETONENSIS. Pl. xviii, 4 *a–d*.

Bull. Nat. Hist. Soc. of N. Brunswick, vol. iv, p. 409, pl. xviii, figs. 4 *a–d*.

Shell of about two or more whorls, the outer whorl large and moderately expanded. Orifice somewhat enlarged and strongly emarginate on the dorsal side by a sharp V-shaped sinus. Sides of the opening strongly arched upward between the dorsal and ventral sides. No distinct keel.

*Sculpture.*—The surface is diversified with numerous rounded ridges concentric to the umbo, with flat spaces between; there is a sharp, narrow furrow along the crest of each ridge; the ridges near the orifice are sharper and more crowded than farther back on the whorl; here there are about three in the space of 2 mm., but towards the mouth about four. The fine sculpturing of the surface appears to be a minute granulation.

*Size.*—Length from the inner part of the last whorl to the lateral edge of the lip, 20 mm. Width across the shell from the dorsum to the inner part of the last whorl, 12 mm.

*Horizon and locality.*—Fine gray shale of Assise C, 3 $c^2$ at McLeod brook, Boisdale, N.S.

The characters of this shell are obscured by flattening in the shale. The umbo appears to be excentric, and it resembles *B. Clerti*, Bergeron, of the Lower Ordovician of the Montagne Noire in Southern France,‡ but has fewer whorls. Similarly to that species, the ridges on the shell are more distant from each other on the upper part of the main whorl than towards the aperture. I could not detect any flattened ridge along the keel of the dorsum.

This shell is distinct from *B. arfonensis*, Salter, by the sharp angulation at the dorsal line, and the striæ that cross it are angulated, not arched.

* Quart. Jour. Geol. Soc., London, vol. xxix, No. 113, p. 50, pl. iii, figs. 30-32.

† Memoir cited, p. 53, pl. x, figs. 15, 15*a*, 15*b*.

‡ Etude géologique du Massif Ancien situé au sud du Plateau Central, J. Bergeron, Paris, 1889, p. 343, pl. iv, figs. 10 and 11.

### Bellerophon semisculptus. Pl. XVIII, fig. 5.

Bull. Nat. Hist. Soc. of N. Brunswick, vol. iv, p. 410, pl. xviii, fig. 5.

Bellerophon semisculptus.

Only the last whorl known. This is free from the inner part of the coil. The proximal part is smooth with faint concentric undulations of growth.

The lines of growth arch backward toward both ventral and dorsal side, and at the dorsum there is an elevated flattened keel, separated from the lateral slopes by a slight furrow; the striæ that run backwards to this keel traverse it at right angles.

*Sculpture.*—The outer two-thirds of the whorl is marked by sharp-edged, concentric ridges of growth; at first there are about four in the space of a millimetre, then they become more distant with flattened spaces between, and toward the orifice of the shell there are about two ridges in the same space. Between the ridges, and on the smooth part of the whorl, the surface of the shell is minutely granulated.

*Size.*—Only one example is known, which is 7 mm. across from the back of the whorl to the mouth, and 6 mm. across from the ventral side of the mouth to the dorsal keel.

*Horizon and locality.*—In fine gray shale of Assise C. 3 $c^2$ at McLeod brook, Boisdale, N.S.

Compared.

This species resembles *B. hippopus*, Salter, of the Arenig horizon in Wales. It differs in its smaller size and in the very regular ridges of growth, there being no alteration of weak and strong ridges. From *B. arfonensis*, of the same author, it differs in the raised keel in place of a depressed band along the dorsum.

## OSTRACODA.

### Beyrichia triceps, n. sp. Plate xvi, figs. 4 *a* to *c*.

Beyrichia triceps.

Form sub-semicircular, about one-third longer than wide. Hinge line straight, nearly the length of the valve; valve somewhat oblique, the anterior marginal slope being straightened, posterior cardinal slope short, anterior wanting; valve slightly pointed at the ventral edge. Surface raised in three tubercles toward the hinge line; of these the anterior becomes a high narrow ridge, close to the anterior margin, and about half as long as the width of the valve; it is highest in the middle of its length, where it is crowned by a small (ocular?) tubercle; one example shows several colored spots (in place of one, which is usual) on the mould, along this ridge. There is a narrow marginal fold around the edge of the valve, except at the hinge.

*Sculpture.*—The surface of the test is coarsely granular, but smoother toward the summit of the ridges and toward the hinge.

*Size.*—Length 2 mm.; width 1½ mm.; depth about ½ mm. for each valve.

*Horizon and locality.*—The calciferous gray flags of Band C. 2 *b*, at McLean brook, near Mira River, N. S. Common.

Comparison with other species.

This species is a link between Beyrichona and Beyrichia; the general form and moulding of the shell is similar to that of Beyrichona, but the sharp, high ridge at the anterior end is different from any species of that genus.

It differs from *Beyrichia nana*, Brögg. of the *Ceratopyge limestone (Temadoc horizon), in its larger size, broader valves, and in having a higher ocular ridge. From *B. costata*, Linrs. of the Beyrichia limestone (Ordovician)† in its greater width and sharp high ridge near the anterior margin. From *B. primæva* of the Protolenus Fauna‡ it differs in its smaller size and greater width and in having more prominent lobes.

## TRILOBITA.

AGNOSTUS TRISECTUS, Salt. mut. PONEPUNCTUS. Pl. XVII., figs. 8*a-c*.

Bull. Nat. Hist. Soc. of N. Brunswick vol. iv., p. 278, pl. v. figs 8*a-c*.

Agnostus trisectus, mut. ponepunctus.

This form grows to a larger size than the type as figured by Tullberg, and differs in several respects. The reticulation on the head-shield does not show a net-work near the glabella, but detached irregular furrows; opposite the posterior half of the glabella the ornamentation is scarcely more than small, sparse, irregular pits. The posterior end of the glabella is wider than that of the European form, and there are lateral lobes near the front of the main lobe.

In the pygidium there are also differences; the sculpturing of the side-lobes is scarcely more than shallow, open pits, faintly visible, and there is a small tubercle at the end of the rachis, which overhangs the rachial furrow. Examples of the pygidium showing the inner surface, have as many as nine paired pits along the inner furrow of the posterior lobe of the rachis, showing that that lobe is composed of numerous somites.

*Size.*—The shields of this mutation of *A. trisectus* attain a length of 8 mm.

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*Die Silurisch. Etagen, 2 und 3, p. 55, tab. XII, fig. 15.

†Kongl. Svensk vetenskapsakad. Handl. bd. 8 no. 2, p. 85, tafl., figs. 67, 68.

‡Trans. Roy. Soc. Can., 2 ser., vol. IV, sec. IV, p. 133, pl. I, figs. 2*a-c*.

*Horizon and locality.*—In bituminous limestone bed of the Band C. 3*b*, at McAdam shore, Escasonie, Cape Breton.

A singular condition of preservation of the test of this species is the rarity of remains of the thorax. Among two dozen heads and three dozen tails of this species, only one joint of the thorax was observed.

Larval characters.

*Larval characters.*—The reticulation or furrowing of the cheeks, which is so obvious a character of adult head-shields, becomes less and less pronounced in the small heads, and disappear in minute ones. Faint furrows are impressed at the sides of the main lobe of the glabella, opposite the median tubercle, showing a somite here to which this tubercle belongs; the examples are $1\frac{1}{2}$ mm. long, in which this is apparent.

A pygidium $\frac{3}{4}$ mm. long, shows a comparatively short rachis of two segments of which the anterior is dominated by a low ridge-like tubercle; no true anterior lobe, such as is found in adult shields, can be detected at this stage. The posterior lobe, by faint tubercles at the sides is shown to be composed of at least two somites, yet the trisected condition of the rachis is already apparent.

### Mut. GERMANUS.

Bull. Nat. Hist. Soc. of N. Brunswick vol. iv. p. 279.

Mutation germanus.

This interesting form has many points of resemblance to *A. trisectus*, and is of nearly the same size, but yet is not trisected on the posterior lobe of the rachis of the pygidium. This form and mut. *ponepunctus* sometimes occur scattered over the same surface of rock, but more frequently are distributed on different surfaces. The smoothness of the slopes of the shields and the absence of trisection in the posterior lobe might lead one to think it a different species from mut. *ponepunctus* and from *A. trisectus*, type, but the tubercle at the end of the rachis of the pygidium, peculiar so far as the author knows to the Cape Breton forms, leads one to think they belong to one species.

*Horizon and locality.*—In Band (C. 3*b*) at Escasonie shore, East bay, N.S.

Compared with type.

Since writing the above I have received a letter from Prof. J. E. Marr, of St. John's College, Cambridge, who has had the examples of *A. trisectus*, in the Woodwardian Museum examined, and also those of the Geological Museum in Jermyn street, London; on none of these is there any trace of a tubercle at the extremity of the mid-lobe of the pygidium. This indicates a closer relationship between the two Canadian forms than is borne by either of them to the type, though the apparent difference

seems to be greater; it appears also to show that the American mutations arose independently of the typical forms, from the Longifront phylum. The indication is similar to that given by the development of *Anomocare stenotoides* from the Olenoid phylum, *i. e.*, a tendency to the independent development of similar forms at particular stages in geological history.*

The two Canadian varieties contrasted.

The differences of mut. *germanus* from *A. trisectus-ponepunctus*, are the following. The head-shield is more strongly arched, stiffer and smoother; the pygidium is *not* trisected on the posterior lobe of the rachis, thought faint furrows may sometimes be traced on one side or the other. It differs from the European type of *trisectus*, in that the median lobe traverses the middle part of the two anterior segments, thus interrupting the dividing furrow between these segments, and it differs also in its smooth, stiff shields.

This mutation shows a considerable resemblance to *A. princeps*, Salt. † But Salter is emphatic in stating that there are no marginal spine (nevertheless two of these figures show such spines, (perhaps there are two species included under *A. princeps*). The figure of Salter's species which comes nearest ours is 1*b* of plate 5, but in that the tubercle on the glabella is represented as elongated and resting on the middle of the main lobe, while in the Cape Breton form it belongs entirely to the anterior segment or somite of the main lobe.

AGNOSTUS, cf. CYCLOPYGE, Tullberg.

cf. *Agnostus cyclopyge*, Tullb. Sverig. Geol. Undersök, Ser. C. No. 42, p. 26, table ii, fig. 15*c*.

Agnostus cf. cyclopyge.

A single pygidium that corresponds to Tullberg's figure of this species was found in association with the other trilobites of the Peltura Fauna at Escasonie. The posterior lobe of the rachis is quite obliterated, not even showing the little grooves on each side of the front of this lobe, shown in Tullberg's figure.

*Size.*—The example is small, not more than two-thirds of the length of the typical form.

*Horizon and locality.*—In a thin limestone of Band C 3*b* at Escasonie shore East bay, N.S.

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* See. Trans. Roy. Soc. Can. vol. iv, sec. iv, pp. 140-148.

† Mem. Geol. Surv. G. Britain [vol. iii, p. 488, pl. 4 figs 2 and 11*a*, and pl. 5, figs. 1*a* and *b*.

### AGNOSTUS, cf. var. DECLIVIS.

cf. *Agnostus Acadicus*, var. *declivis*. Trans. Roy. Soc. Can. vol. iii, sec. iv, p. 70, pl. vii, figs. 6 *a* and *b*.

Agnostus cf. declivis.

A small species of the Limbatus section of the genus Agnostus, occurs at the Peltura locality on McNeil brook. It is too imperfectly preserved for exact determination, but it carries this type of Agnostus into the Upper Cambrian as *A. bisectus* does the *B. concinnus* type.

Occurring in dark grey shale with *Peltura scarabeoides*, *Ctenopyge (lobata ?)* and *Agnostus (trisectus ?)* McNeil brook, Mira river in Band C. 3*b*.

## PARABOLINA, Salt.

### PARABOLINA DAWSONI. Pl. XVII, figs. 6*a–f*.

Bull. Nat. Hist. Soc. of N. Brunswick., vol. iv, p. 282, pl. v, figs. 6*a–f*.

Parabolina Dawsoni.

The *middle piece* of the *head-shield* is sub-trapezoidal in form, is strongly arched in front, where there is a narrow but prominent marginal fold, and has triangular projecting posterior angles. The glabella is cylindro-conical in outline, and is as broad as its length and half of the width of the occipital ring; it is as broad opposite the first furrow as at the occipital ring, and thence narrows more rapidly to the front, which is strongly arched; the front margin is correspondingly arched, and the intervening area of the fixed cheek is therefore of nearly even breadth around the front of the glabella; the width of this area on the median line is two-ninths of the length of the glabella. The glabella is marked by three pairs of furrows, nearly equidistant, and having the inner extremities turned backward; the inner half of the posterior furrow is more evenly impressed, and the anterior furrow is more distinct in the outer half, which is at the anterior corner of the glabella. The occipital ring is of nearly even breath, has a tubercle on the axial line, and has a triangular lobe at each end on the anterior side, due to a faint furrow that crosses the ring diagonally. The fixed cheek is triangular, and at the front of the eyelobe as wide only as two-thirds of the space between the glabellar furrows; the eyelobe is opposite the space between the second and third furrow of the glabella, and there is a short ocular fillet extending diagonally out to it from the anterior corner of the glabella. The posterior marginal furrow and fold are distinctly marked.

Description of the parts.

The *movable cheek* is more strongly arched in front than behind, and like the middle piece of the head-shield, has a sharp, narrow marginal fold; the area of the cheek is somewhat wider in front than behind, and the proportion in length of the three cords of the facial suture is 1, 1, $2\frac{1}{2}$.

There is a narrow, sharp genal spine, of unknown length, projecting backward from the outer angle of the cheek.

The *thorax* has narrow rings with narrow pleuræ, having sharp backward-curved points. The thoracic rings have triangular lobes at the outer ends and a median tubercle, like the occipital ring. The pleuræ have a sharp, oblique furrow, extending to the geniculation.

A *hypostome* supposed to belong to this species has a large, oval anterior lobe, narrower behind; an upturned margin borders it at the sides, but at the back is broken away.

The *pygidium* has two well marked rings to the rachis, each surmounted by a tubercle, and a posterior lobe which is obscurely divided into two somites. The side lobes have two faintly marked ribs with diagonal grooves, and the borders of the side lobes are flattened. A small backward, outward projecting spine is placed at the anterior corner, on each side.

Sculpture.

*Sculpture.*—The area in front of the glabella is ornamented with forking and anastomosing raised lines, radiating toward the anterior margin. The glabella appears smooth, but under a strong lens is seen to be minutely punctate, or even obscurely reticulate with raised lines. The movable cheek, like the area in front of the glabella, is ornamented with distinct raised lines, giving a reticulate surface; toward the marginal fold these lines are forked and directed outwards.

The reticulation of raised lines is more distinct on the interior than on the exterior surface of the test. A similar but faint reticulation is visible on the front half of the fixed cheek. The surface of the glabella, seeming smooth to the naked eye, when viewed with a lens appears to the faintly marked with scattered pits or depressions. The front and lateral marginal fold of the head-shield, when viewed with a strong lens, is seen to be minutely striate lengthwise of the fold.

***Size.***—The head-shield figured is not the full size of this species, for some pleuræ show that it grows to a size one-quarter longer.

***Horizon and locality.***—In limestone of Band C. 3*b* at Escasonie shore, East bay. N.S.

Compared with other species.

This species is closely allied to *P. acanthura*, Ang.,* from which it differs in the following respects: The area in front of the glabella is wider and more strongly arched, and the fixed cheek is more pointed at the posterior outer angle. In the free cheek the rim is more strongly arched in front, and has less width behind. The joints of the thorax

* Palæontol. Scand., p. 49, pl. xxvi, fig. 9. Also Om Acerocare, Moberg & Möller, Stockholm, 1898, p. 239 tafl. 12, figs. 1*a* and 4*a*.

have tubercles, or, in some cases, spines on the rings. The pygidium has a median tubercle on each of the first two joints, and the marginal spines, of which only one pair is known, are directed outward rather than backward. In other respects the two species, in so far as comparisons can be made with the imperfect material obtained, are much alike.

This species is distinguished from *Protopeltura acanthura*, var. *tetracanthura*,* by the broad area in front of the glabella, and by its broader pygidium with fewer joints. From *Parabolina heres*, var. *lata*,† it differs in the arched anterior border fold, and narrow fixed cheek. From *P. heres*, as depicted by Brögger, it differs in its shorter pygidium of fewer joints.‡ From *P. acanthura*, as figured by the same author, in its more quadrate glabella, and in the tubercles on the rings of the rachis of the pygidium.§ From *P. heres*, as shown by Moberg and Möller, in the absence of strong reticulation on the surface of the fixed cheek, and the fewer joints in the pygidium.|| From *P. acanthura*, as figured by these authors, in the arched front of the head-shield, and in the presence of tubercles on the rachis of the pygidium.**

From *Parabolinella Plantii*, Salter, as figured by F. R. C. Reed, it differs in its arched front margin, broader glabella, differing glabellar furrows, and in possessing pygidial spines.††

If it were not for the pair of marginal spines at the front corner of the pygidium, this species, from the flattened side lobes of the pygidium and other features, would fall under Brögger's sub-genus Parabolinella.‡‡

### PARABOLINELLA? QUADRATA, Pl. XVIII, fig. 7.

Bull. Nat. Hist. Soc. of New Brunswick, vol. iv, p. 411, pl. xviii, fig. 7.

Parabolinella (?) quadrata.

Middle piece of the head shield subtrapezoidal in outline. Anterior marginal fold narrow; width of the front area of the cheek, one-fourth of the length of the glabella. Glabella quadrate in front, and as wide there as its length, but considerably narrower at the posterior furrow. Posterior and second furrow directed backward, and deeply impressed in the outer third, but not reaching the margin of the glabella. Eyelobe slightly elevated, extending opposite the two anterior furrows of the gla-

* Trans. Roy. Soc. Can., vol. ix, sec. iv, p. 53, pl. xiii, figs. 8*a-c*.
† Trans. Roy. Soc. Can., vol. ix, p. 51, pl. xiii, figs. 6*a-f*.
‡ Die Silurish. Etagen 2 und 3, p. 101, tab. i. fig. 13*d*.
§ Idem, p. 106, tab. 14, 14*c*.
|| Om. Acerocarezonen, Stockholm, 1898, p. 267, tafl. 12, figs. 8*a*, 11*a*.
** Idem, p. 259, tafl. 12, figs. 1*a* and 4*a*.
†† Geol. Mag. New ser. dec. iv, vol. vii, p. 363, fig. 1.
‡‡ Ibid new ser. dec. iv, vol. iii, p. 303.

bella; ocular fillet broad and indistinct. Fixed cheek triangular, about as wide behind as the length of the dorsal suture behind the eyelobe. The posterior marginal furrow is faintly marked. The dorsal suture arches outward in front of the eyelobe, and behind it goes direct backward and outward to the posterior margin, and in that part is nearly half as long again as the cord of the eyelobe and anterior part of the suture together.

The pleuræ are long and narrow, and have a sharp, deep furrow, which is nearest the posterior margin; they are sharply bent, and pointed at the ends. The ring is pushed up in the middle into a pseudo-tubercle, such as is common on the occipital ring of species of this genus.

*Sculpture.*—A row of faintly marked tubercle-like swellings are found along the bottom of the anterior marginal furrow. The middle piece of the head-shield in all its parts appears smooth, except for a minute punctation.

*Size.*—Middle piece of the head-shield 25 mm. long. It is 25 mm. wide at the anterior and about 40 at the posterior end.

*Horizon and locality.*—In gray shale of Assise *C.* 3 $c^2$, at McLeod brook, Boisdale, N.S.

ed
her

This species is near *Parabolinella limitis* of Brögger. It differs in its longer and more quadrate glabella. The fixed cheek also is longer and the eyelobe less prominent. Apparently also it is a larger species.

From *P. rugosa* of the same author it is distinguished by its more quadrate glabella and by a different arrangement of the glabellar furrows. It resembles this species in the possession of a comparatively wide area in front of the glabella. The glabella so wide in front (one-seventh wider than at the posterior lobe), recalls that of *Ceratopyge forficula*, Sars., of a similar horizon in Sweden.*

**PARABOLINELLA (?) cf. LIMITIS, Brög.**

linella
tis.

**The middle piece of the head-shield of a young individual which, by its form, agrees with the figures of this species, given by Professor Brögger,† was found in these beds. Only one example was met with. The size of the shield is 2½ x 4 + mm. The interior of the shield shows three pairs of furrows, a strong ocular fillet, and a well-marked eyelobe.**

* Die Silureschen Etagen 2 und 3, p. 14, tab. 3, fig. 3.
† Ibid p. 102, tab. iii, figs. 2 and 4.

SPHÆROPHTHALMUS FLETCHERI. Plate xvii, figs. 7*a–f*.

Bull. Nat. Hist. Soc. of New Brunswick, vol. iv, p. 280, pl. v, figs. 7 *a–f*.

Sphæroph-thalmus Fletcheri.

General outline of the *middle piece of the head shield*, square, with a large, nearly cylindrical, glabella, which in front overhangs the narrow marginal fold. The glabella has a width two-thirds of the length of the glabella and occipital ring together. A strong furrow divides off the third of the glabella. The occipital ring is narrower than this lobe of the posterior glabella, and bears a tubercle at the middle.

The fixed cheek is much drawn in behind and then arches downward and outward to the posterior margin. The front of the cheek is tumid and traversed by an ocular fillet directed diagonally backward.

Parts of this trilobite.

To the *movable cheek* is attached the large globular eye, placed near the back of the cheek, the cheek is prolonged outward into a flat spine of abnormal size; this spine is as wide in the front quarter as the cheek itself, and curves backward in a regular arch at first, but toward the extremity becomes nearly straight. Of the two ribs which traverse it, one is an extension of the posterior marginal fold, and the other is a prolongation of the elevated middle part of the cheek. The flattened area on each side of the spine is a special expansion of the anterior and posterior marginal folds, and towards the tip of the spine, narrows more rapidly than the area occupied by the ribs; of the flat areas, the outer is hollowed on the upper side, and the inner one somewhat convex on that side, especially toward the base of the spine.

A young *hypostome*, imperfect at the front, which may belong to this species, has a narrow, elevated obconical anterior lobe extending two-thirds of its length; and an encircling, more depressed posterior lobe, occupying the rest of the hypostome; both lobes are convex, and no border fold is visible.

The *pygidium* of this species is broadly triangular, and has a strong obconical rachis of three segments, the third nearly as long as the two anterior. These latter have each an obscure lobe at each side. The side lobes are narrow triangles, with a tubercle at each anterior outer corner. There is a distinct but narrow border fold at the sides and posterior end of the pygidium.

*Sculpture.*—This is exceedingly minute and appears to consist of very fine granulations with a smooth, shining surface on the front lobe of the glabella; this part of the glabella shows occasional scattered small tubercles.

*Size.*—Length of the middle piece of the head shield 3 mm. width, 5 mm. Length of the movable cheek, 3 mm. ; width, exclusive of the genal spine, 2½ mm. Width of the genal spine, 2½ mm. ; length, 25 mm. Length of the pygidium, 1½ mm. ; width, 2 mm. Length of a young hypostome, 1½ mm. ; width, 1 mm.

Compared with other species.

*Locality and horizon.*—Limestone bed in C. 3*b* at McAdam's shore, Escasonie, Cape Breton, N.S.

This form is distinguished from the mutation *Canadensis* of *S. alatus*, found in the upper Cambrian shales at St. John,* and from the type of that species, by its long, flat and very wide, falcate genal spine. It agrees nearly with a spine and free cheek figured by Linnarsson, but not referred to any species. The cheek portion of *S. Fletcheri* is very small compared with the spine, which is stiffened by the two sharp ridges that run along the middle ; these ridges occupy about a third of the width of the spine, the rest being flat.

The pygidium of this species differs from that of the type of *S. alatus* as figured by Linnarsson in the possession of narrow side lobes (about as wide as the marginal fold) ; that author's figure gives no side lobes, the marginal fold being in contact with the rachis.†

For numbers, this is the dominant species in the trilobite bed at McAdam shore, as will be seen by the following proportion of forms found on five square inches of surface of one of the layers.

Comparative abundance.

| | | | |
|---|---|---|---|
| Sphærophthalmus Fletcheri | 30 | heads. | 24 cheeks. |
| Agostus trisectus, chiefly the mut. ponepunctus | 9 | " | 1 pl 6 pyg. |
| Ctenopyge pecten | 8 | " | 3 cheeks. |
| Peltura scarabeoides | 1 | " | 4 pl. 1 pyg. |
| Parabolina Dawsoni | 1 | " | |

**All the heads of Sphærophthalmus were** not counted ; several were so **small that the generic characters were not** well shown.

SPHÆROPHTHALMUS ALATUS, Boeck.

Sphærophthalmus alatus.

1838. *Trilobites alatus*, Boeck, Gæa. Norveg., p. 143.
1848. *Olenus humilis*, Phill. Mem. Geol. Surv., vol. ii., pt. i, p. 55, figs. 4, 5, 6 and p. 347.

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* Trans. Roy. Soc. Can. vol. xi, sec. iv, p. 107, pl. xvii, figs. 11*a* and *b*, 12*a* and *b*.
† Geol. förening, i Stockholm Förhandl, 1880 No. 60 Bd. No. 4, p. 2 fig. 14.

1854. *Sphærophthalmus alatus*, Ang. Pal. Scand., p. 49, t. xxvi., fig. 9.
1866. *Olenus (Sphærophthalmus) humilis*, Salt., Mem. Geol. Surv. G. Brit., vol. iii, p. 302, t. v., fig. 12.
1880. *Sphærophthalmus alatus*, Linrs. Geol. förening i Stockholm Förhandl, No. 60; Bd. v., No. 4, p. 7, t. 1, fig. 6–10.
1893. *S. alatus* var. *Canadensis*, Trans. Roy. Soc. Can., vol. xi., p. 107, pl. 17, figs. 11 *a* and *b*.

This common and widespread species of the Upper Cambrian has been found at two points in the eastern provinces of Canada, viz., at St. John, N.B., and at McNeill brook, near the Mira river in Cape Breton. It is found both in the dark gray slates at the latter locality and in some of the thin limestone bands found in these slates.

The Cape Breton material is not sufficient to determine whether the variety is represented there, or the original form.

## CTENOPYGE, Linrs. 1880.

CTENOPYGE PECTEN, Salter. Pl. XVII., Figs. 5 *a* and *b*.

1864. *Olenus (Sphærophthalmus) pecten*, Salt. Mem. Geol. Surv. G. Brit., Dec. xi., p. 9, t. viii., fig. 11, 13. Ctenopyge pecten.
1866. *Olenus (Sphærophthalmus) flagillifer*, Salt. Mem. Geol. Surv. G. Brit., vol. iii, p. 301, t. 5, figs. 3, 9.
1866. *Olenus (Sphærophthalmus) alatus*, Salt. Loc. cit., p. 302, t. 4., fig. 3, 3*a*.
1891. *Ctenopyge pecten*, Trans. Roy. Soc. Can., vol. ix., p. 58.

This species, which was only doubtfully recognized by fragments in the limestone lintels of the black slates of Div. C. 3*b*, at King street, St. John, is clearly present in the corresponding assise in Cape Breton. The peculiar herring-bone-like rachis of its broad pygidium is frequently met with among other fossils of this horizon on the Escasonie shore. Linnarsson asserts that the segment of the side lobes in this pygidium are quite free from each other, and are entirely analagous to the pleuræ of the thorax; yet the rachis must be strongly cemented, for it is a part not infrequently met with when no other portion of the pygidium can be recognized. This, we may assume, is owing to the fact that the almost free lateral segments have, owing to their slenderness, been broken off. A rough copy of Linnarsson's beautiful figure is reproduced on one of the plates with article Pl. XVII., fig. 5 *b*.

This species is quite abundantly mingled with *Sphærophthalmus Fletcheri* on surfaces of the bituminous limestone at the Escasonie shore. Most of Occurs with preceding species.

the full grown examples agree with Salter's indication of the size, but occasional larger head shields are found, that do not appear to differ essentially from the type; these have a middle piece to the head shield that is 3 x 6 mm. measured at the axial line, but 3 x 7 mm. at the longest part of the fixed cheek.

All the pygidia seem to have been broken up, and, are rare compared with the head shields; three or four examples of the comb-like rachial part of the tail shield were seen.

The young (or a small variety) differ considerably from the larger ones in the form of the glabella; this part is proportionately shorter (which for a larval condition is unusual) and the front lobe is rounder and more prominent.

*Horizon and locality.*—The limestone layers in the bottom of Band C. 3*b*. at Escasonie shore, East bay N.S.

PELTURA SCARABEOIDES, Wahlenb.

1821 *Entomostracites scarabeoides*, Wahlenb. Petrif. Tell. Suec. p. 41 t. i fig. 4.

1822 *Paradoxides scarabeoides*, Brongn. Hist. nat. des crust. foss. p. 34 t. iii fig. 5.

1827 *Olenus scarabeoides*, Dalm. K. Vet. Akad. Handl 1826, p. 72.

1840 *Peltoura scarabeoides*, Milne-Edw. Hist. nat. des crust. tom. iii, p. 344.

1847 *Petura scarabeoides*, Corda, Monog. der Böhmisch. Trilobit. p. 127, t. vi, fig. 68.

1866 *Olenus scarabeoides*, Salt. Mem. Geol. Surv. G. Brit. vol. iii, p. 301, t. 15, figs. 2-5.

1886 *Peltura scarabeoides*, Wahl., Trans. Roy. Soc. Can., vol. iv, p. 147; vol. viii, p. 126; vol. ix, p. 53.

This characteristic species is that by which the presence of Cambrian rocks was first recognized in Cape Breton. It occurs at McNeill brook, east of Mira river and also at the Escasonie shore, in both cases marking the presence of the Assise C. 3 *b*. of the St. John terrane.

TRIARTHRUS BELLI, Pl. XVIII, fig. 8.

Bull. Nat. Hist. Soc. of New Brunswick, vol. iv, p. 412, pl. xvii, figs.

Only the middle piece of the head-shield is known; this is subquadrate, with narrow cheeks and anterior margin.

There are traces of a very narrow anterior marginal fold, and behind it a narrow convex anterior area of the cheeks. The *glabella* is quadrate, rounded in front, and bears three pairs of furrows, which are progressively less bent backward from the back to the front pair, though the two posterior pairs are already parallel; the anterior pair are quite faint, and more strongly arched than the others. The glabella is somewhat keeled along the axial line. The *fixed cheek* is long and quite narrow, and is separated from the front area by a shallow furrow; at the eyelobe it is about one-third of the width of the glabella, and at the back about one-half. The eyelobe is long, narrow and obscure. The posterior marginal fold is narrow but prominent. The occipital ring is bent forward at the ends, and has a tubercle on the axial line.

*Sculpture.*—This species has a smooth test, but under a small lens shows a somewhat uneven surface.

*Size.*—Only one example known; in this the middle piece of the head is 6 mm. long and 10 mm. wide at the back. Scarce.

*Horizon and locality.*—Fine gray shale of Assise C 3 $c^2$ at McLeod brook, Boisdale, N. S.

Compared with other species.

This species is clearly distinct from *T. Beckii*, Green, by its narrower cheek and wider space between the sutures in front. It resembles more closely *T. Angelini*, Linrs, but it differs from the type of that species as figured by Linnarrsson in the wider frontal area of the cheeks and its convex front margin; also in possessing three pairs of furrows, &c. From the Norwegian form, referred to this species by Brögger, it differs in its narrower glabella, rounded front, and in having three pairs of furrows, though the third one is faint; the anterior area of the fixed cheek is wider, and is separated from the rest of that cheek by a shallow furrow; it is, however, nearer this form than to any other known to me.

Billings does not describe *T. Fischeri*, except by contrast with other species (Upper Ordovician chiefly), but from his figure of that species, the Cape Breton form differs in the posterior marginal fold, which is not turned forward, like *T. Fischeri*. It also differs from that species in having an anterior buccal area and in the absence of pits on the front of the glabella.*

I refer this species to Triarthrus rather than Parabolinella because of the narrow fixed cheeks, the long, backward turned eyelobes and the regular, straight furrows on the glabella.

* Palæoz. Fossils, vol. 1, p. 291, fig. 280.

ANGELINA ? sp. ? Pl. XVIII, fig. 9.

Bull. Nat. Hist. Soc. of N. Bruns'k., vol. IV, p. 413, pl. XVIII, fig. 9.

While we have no adult of this genus from the Tremadoc of Cape Breton, there is a young larval shield which seems to agree reasonably well with the characters of this genus by its suture and general outline. Only the head shield has been preserved. This is narrow, as are all its parts. The eyelobes are curved and linear, starting from near the front of the glabella in a heavy ocular fillet, the eyelobes are placed about the middle of the cheek. The movable cheeks have extended spines, and are cut off in front by the curving suture. The glabella is ridged along the middle, and has traces of three pairs of faintly marked furrows. The occipital ring is narrow and weak.

*Sculpture.*—The surface appears smooth.

*Size.*—Length of this larval headshield, 5 mm. (or to the end of the spines 8 mm.); width, 7 mm.

*Horizon and locality.*—Gray shale of Assise *C* 3 *c* 2 at McLeod brook, Escasonie, N. S.

## ASAPHELLUS Callaway.

ASAPHELLUS HOMFRAYI, var. Pl. XVIII, figs. 10*a-e*.

cf. *Asaphus Homfrayi*, Salt., Mem. Geol. Surv. G.B., vol. iii, p. 311 pl. viii, figs. 11-14, 1866.

Bull. Nat. Hist. Soc. of New Brunswick, vol. iv., p. 413, pl. xviii., figs. 10*a-e*.

Salter's description of *Asaphellus Homfrayi* is as follows:

"Asaphus (Isotelus) long-oval, gently convex, having the head subangulate in front, and having short [genal] spines. Facial suture within the margin. Eyes submedian [near the mid-length of the shield], small. Pygidial axis long, somewhat prominent at the apex. It is three inches long and one and a half broad."

The addition to this description in Salter's trilobites is as follows:

"The head is more than a third of the whole length, and longer than the thorax, which in its turn, is *longer** than the caudal shield. The head is semi-oval, rather pointed in front, and has *very short* posterior spines; it is broadly depressed around the margin. The glabellar portion is scarcely marked out; the eyes are placed nearly half-way up the head; they are small (two lines long), the facial sutures curving out boldly beneath them, and cutting the posterior margin more than half way out from the axis.

Above the eye they form a narrow ogive, and nearly follow the front margin. On the underside of the head the vertical furrow on the epis-

*The italics are inserted to mark the points of difference from the Canadian variety.

tome shows distinctly through the cast. The labrum [hypostome] is imperfect, but exhibits a strong marginal groove, and two small lateral furrows.

The body rings have the axis as broad as the sides, and moderately convex. The pleuræ are flat as far as the fulcrum, truncate at their ends, and have but a slight groove, which reaches two-thirds of the length. The fulcrum is at one-third in front, and less than half way out in the middle pleuræ.

The caudal axis extends three-fourths down the smooth tail, very indistinctly marked above, but in some specimens crossed by several faint rings, and is always prominent at the tip."

Other points in which the Canadian variety differs.

The Cape Breton form, by its hypostome, it is clearly within Callaway's genus asaphellus. Allowing for the distortion of the type species, figured by Salter, it is quite as large.

Certain features, not mentioned by Salter, are characteristic of the Cape Breton form. The glabella is somewhat ridged along the axial line, and its margins more distinct. About one-fifth of the length of the head shield from the back there is a slight but distant prominence (scarcely a tubercle) on the axial line; a fairly marked tubercle is also found on the median line of the axis of the pygidium, at the back of the first ring, and faint traces of similar prominences on succeeding rings.

The genal spines are not as short as Salter's description indicates for the Welsh form for the points are opposite the fourth segment of the thorax; the length of the movable cheek and spine behind the facial suture, is just equal in length to the part of the latter behind the eyelobe.

The eyelobes are variable in position; in the type figured they are just half way between the front and back of the shield; in examples of the narrow form they are, proportionately, further back; and in both forms the width of the middle piece in front is considerably less than at the eyelobes.

In the broad form, the headshield, thorax and pygidium are each of about equal length; others have the pygidium shorter than the thorax by the width of one joint. In the narrow form examples occur in which the pygidium is longer than the thorax. The pygidium has more numerous somites than *A. Homfrayi* as figured by Salter.* From *A. affinis* McCoy (ibid) it differs in having the middle piece narrower in front, and the glabella and axis of the pygidium more markedly elevated.

Young individuals have the pygidium proportionately shorter and wider; one of about 15 mm. in length has a pygidium equal in length to only six

rings of the thorax. The thoracic ring is narrow, for one is equal in length to the breadth of five rings.

### Hypostome.

This for *A. Homfrayi* seems very imperfectly known. A good example of the Cape Breton variety has the following characters:

ome of cies. *Hypostome* 16 x 17 mm. main lobe 11 x 11. No anterior wing or doubleur attachment was observed.

Nearly circular, though wider towards the back than the front. It has a moderately arched oval body, with a broad convex border, wider towards the back. The main body of the hypostome is divided by a pair of diagonal furrows that impress each outward third about two-thirds from the front. Immediately behind these furrows are the maculæ-sharp, narrow ridges, raised above the general level of the hypostome; no ocular facets are visible, but there are several small, obscure pits along the ridge. Were the hypostome in place beneath the glabella, the macula would be opposite the eyelobe of the cephalic shield, but nearer the axialine of the body. The furrow within the border is depressed at the back and bordered by a narrow upturned flange, but there is no emargination, nor does the border project backward in a pair of forks. The hypostome is highest in the middle of the main lobe, and the convex border is bent down in the middle, where it is broadest.

### Development during growth. Young, 2 x 1½ mm.

pment oung. This larval form is interesting as a connecting link between several genera of the Asaphidæ. It may be said to antedate the development of the generic characters. At this stage the carapace had no flattened borders, and the head shield especially was strongly bent down in front and at the sides. The back of the glabella is very distinctly marked out, and here the head-shield is strongly trilobed. About the middle of the glabella, on the inside of the shield a flaring ridge, that appears to be the back part of the eyelobe, runs out on each side from the glabella, and fades away on the surface of the test. At this stage no moveable cheek had been detached, but the genal corner of the shield is somewhat extended into a short point. There are indications of several somites in the head shield; first the neck ring and posterior marginal fold, then a pair of somites indicated by incipient furrows on the sides of the glabella, then the ocular segment.

The thorax, at this stage, possessed two joints, with rounded rings and

In the pygidium, the neopygidium and protopygidium* are distinct; the former has three rings as strongly marked off as those of the thorax, the protopygidium has the same number of obscure somites.

In this larval form, which in development is close to the unsegmented larva, the outline of the headshield distinctly recalls the adult in Illænus and Dysplanus, but the strongly segmented pygidium has an even more generalized meaning.

Young 6 x 5 mm.

This moult already possesses many features of the adult.

A later moult.

The flattened borders are obvious on both shields, and the headshield is broken up into the three principal pieces. The movable cheeks have heavy genal spines, and the course of the suture is functionally that of the adult. The slipping of the cheeks in this example has obscured the eyelobe, which, however, appears to be not far from the glabella. The glabella, though slightly marked elsewhere, is marked off in front by a slope to the flattened margin.

The thorax now has five joints, and the pleuræ has grooves and facets like the adult.

The pygidium has about the same number of segments as in the younger shield, but those of the neopygidium are less prominent than in the younger moult; they are, however, still discernable on the sidelobes, as well as on the rachis. In this, while not agreeing with the genus Asaphellus, they recall many others of the Asaphidæ.

*Size.*—Length of the whole carapace of the adult, 73 mm.. Length of cephalic shield, 26 mm.; of thorax, 21 mm.; of pygidim, 26 mm. Width of cephalic shield, 50 mm.; of thorax, 43-45 mm.; of pygidium, 45 mm.

*Horizon and locality.*—In fine gray shale of Assise C. 3 $c^2$ at McLeod brook, Boisdale, N.S.

## Note on the Young of Asaphellus Homfrayi.

Young of this species like Conophrys Salopiensis of Callaway.

Since writing the above in regard to the young of *Asaphellus Homfrayi* the writer has consulted Dr. Callaway's article on the fauna of the Shinton Shales,‡ and was at once struck with the resemblance between the youngest form here described, and *Conophrys Salopiensis*, and it is clear that the latter is a later stage or development of the former.

* Monograph British Trilobites, p. 165, pl. 24, figs. 6-12.
† Quart. Jour. Geol. Soc. London, vol. xxxiii, p. 652.
* Trans. Roy. Soc. Can. 2me. Ser., vol. iv, sec. iv, p. 145, lines 26, 27.

There is no question that in the Canadian form three rings, of the five that are strongly marked, are still a part of the pygidium; but if they were *free* rings there would be a remarkably close assimilation to Conophrys, the difference being only in the greater number of rings in the thorax of this genus. Looked upon as a developmental stage of Asaphellus this difference is to be expected, as our form is smaller than *Conophrys Salopiensis.*

The differences in the headshield are also of a kind that naturally follow from the two being different stages of development. Dr. Callaway shows the front lobe of the glabella as much more distinct than that of the Canadian form, though he speaks of it as being "hardly distinguishable from the front of the head;" in the Canadian form this lobe is barely discernable, except at the sides of the glabella. Again he speaks of the neck furrow being "deep," whereas in the Canadian form it cannot be discerned, and the lateral furrows are fainter and more embryo-like. *Conophrys Salopiensis* therefore may very well stand as a developmental stage of *A. Homfrayi*, somewhat more advanced than the youngest form ascribed to this species from the Canadian beds. The development of one genus from another in the earliest larval stages is shown in the observations on the development of *Anomocare stenetoides* from an Olenus-like (Acantholenus) larva.*

cases
op-
iscus
mo-

On the other hand, those studies show that Conophyrs or rather Shumardia may be a valid genus, arrested in the phylum from which Asaphellus and Asaphus were elaborated; if so, however, we should be able to find it in faunas from which these genera are absent. Nevertheless it is quite possible that it might be absent from faunas which have the later Asaphi, if the Shumardia stage were passed over in the development of the later forms of this family. Such a case of arrested development, and fixation of larva' as specific characters, seems to be presented to us in the species *Bathyuriscus pupa* of Mt. Stephen fauna,† as well as in *Acantholenus spiniger.**

That the form which we have described as an early moult of *Asaphellus Homfrayi* is Asaphoid, though so far removed from the adult in form, I think is shown by its peculiar glabella, fading away at the front into the frontal area of the cheeks, so that the line of demarkation between the two is not clearly traceable, a very common character in the Asaphoid trilobites. In this form it appears to the writer that the faint crescentic lobe in the front of the glabella is homologous with the front lobe of the glabella and the eyelobes collectively, and that the flaring anterior

* Bull. Nat. Hist. New Brunswick St. John, 1898. No. xvi, p. 10.

of the dorsal furrows represent the posterior half of the eyelobes. The obscurity of the occipital furrow is also an Asaphoid character.

If Conophrys is a valid genus Mr. E. Billings' genus Shumardia has precedence of it by five years. *S. granulosa* (Billings) of the Quebec group appears to be a diminutive trilobite of the same type, and from near the same horizon.* *S. glacialis*, of the same author, probably belongs to another genus.† Shumardia a similar form.

The late Dr. Henry Hicks, described from the Tremadoc group in South Wales, two species of "Niobe," which Prof. W. C. Brögger refers to Asaphellus‡; one of these, *N. Menapiensis*, is too large to compare with the Cape Breton species; the other, *N. solvensis*, differs in the form of the movable cheek, and of the hypostome.

### Asaphellus (?) planus, Pl. XVIII, fig. 11.

Bull. Nat. Hist. Soc. of New Brunswick, vol. iv, p. 419, pl. xviii, fig. 11.

A broad oval species with smooth shield and prominent eyelobes. Asaphellus planus.

The head shield is semicircular, with strong cheek spines. It is about twice as wide as long, and has a broad flat margin.

The middle piece of the head shield is narrowed in the middle by the eyelobes being placed close to the side of the glabella.

The facial sutures are strongly arched out in front of the eyelobe and turning, meet along the front margin; the front area of the cheek thus left, is wider than the middle piece at the eyelobe, and three-fifths of the width at the back of the middle piece. The suture curves out boldly behind the eyes, turning inward again near the posterior margin, which it cuts about a third of the distance from the outer margin of the head shield.

The glabella is level with the cheeks, except at the front, where it slopes down to the flattened anterior margin. The eyelobes are strongly elevated, short, and placed about half way from the front of the shield. There is a minute tubercle on the axial line one-quarter from the back of the head. The posterior marginal furrow is short and shallow, and the occipital ring narrow and obscure.

The movable cheek behind the eyelobe is nearly as wide as the glabella; the front runs beneath the front margin of the middle piece in a wide semi-doubleur that extends to the axial line. Posteriorly, it is Description of its parts.

* Ibid. vol. i, p. 283, fig. 270.

† Palæozoic Fossils, vol. i, p. 92, fig. 83.

‡ Euloma-Niobe Fauna, Christian '96, p. 47.

lengthened into a genal spine, which, from the facial suture to the point, is as long as the posterior extension of the suture behind the eyelobe.

The movable cheek, under the eyelobe, carries a convex band of several rows of minute ocular facets arranged diagonally; those in front of the middle of the band run diagonally upward and forward, those behind the middle run diagonally upward and backward.

The thorax of eight joints has long, narrow segments, terminating in rounded points, strongly facetted; the ring of the middle segment is about as long as the pleuræ; the pleuræ are bent (but scarcely geniculate) at one-half of the length of the first segment; they bear a quite shallow furrow directed backward; each ring of the thorax has a narrow articulating band.

A thorax and pygidium of smaller size, supposed to belong to this species, has the following characters; The pygidium is broadly semi-circular and no axis is visible; a slight protuberance one-third from the posterior end indicates the termination of the rachis; the sides lobes are sloped down to a somewhat flattened margin. On each side lobe there is a shallow groove near the front.

The hypostome in this species is unknown, therefore the reference to Asaphellus is provisional.

*Sculpture.*—The surface of the shell of this trilobite is smooth or minutely punctate. The underside of the movable cheek has a rugulose surface on the upper part, and a finely concentrically striated band on the slope outside of this; the flattened band is covered with widely spaced anastomosing raised lines, parallel to the margin of the shield.

from frayi. The composition of the test in this species is different from that of A. *Homfrayi*, which has a shining and polished surface as preserved in the shale; this, on the contrary, had a dull surface, and appears to be more calcareous, as there is little but a film of the shell substance left, where the containing shale has been exposed to weathering.

*Size.*—Length, about 70 mm.; width, about 55 mm.; length of head shield about 26 mm.; of the thorax, 20 mm.; of the pygidium, about 24 mm, The pleuræ are about 45 mm, long, and the pygidium of about the same width. Scarce.

*Horizon and locality.*—The gray shales of Assise *C.* 3 c.[2] at McLeod brook, Boisdale N.S.

*A. (?) planus* is distinguished from *A. Homfrayi*, var. by its broader glabella, more prominent and more distant eyes, broader and less pointed front to the middle piece of the headshield, more obscure neck furrow.

narrower thoracic rings, and the smooth and obscure axis of the pygidium.

This form might be referred to *Niobe*, but for the obscurity of the glabella (and the almost entire absence of rachis to the pygidium, if we are right in referring the smooth pygidium to this head and thorax). This form cannot belong to *Platypeltis*, Cal., because it has eight segments, and no frontal enlargement of the glabella is traceable; on the contrary, the glabella is conically rounded, as in Asaphus.

### Ctenichnites bisulcatus, n. sp.

Ctenichnites track.

This track I have not seen elsewhere in the Cambrian rocks. The furrows are arched like those of *C. ingens*, but only two furrows are found together and these a little over two inches apart. The impression of the outer one fourteen inches or more in length, was much stronger than the inner; the latter was visible for a length of only three inches; the outer track is more strongly arched at the ends than elsewhere; the chord of the arch is about half an inch from the highest part of the arch.

*Horizon and locality.*—On a flag of the Johannian Division. *(C. 2a.)* Falls of MacMullin brook, Indian brook, Escasonie N.S.

**Synopsis of the Species of the St. John Terrane in Cape Breton, with the horizons at which they are found.**

| Synopsis of the Cape Breton species of the St. John Terrane. | Name of Species or Variety. | Page. | 1 Acadian. | 2 Johannian. | | | 3 Bretonian. | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | *c* | *a* | *b* | *c* | *a* | *b* | *c* | *c*² |
| | | | Etcheminicus Sub-zone. | | Forchhammeri Zone. | | Parabolina Zone. | Peltura Zone. | Dictyonema Zone. | Asaphellus Zone. |
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| | L. ——— lævis γ. lens | 207 | | | | | × | | | |
| | L. ——— ——— v. grandis | 200 | | | | | × | | | |
| | L. ——— concinna | 203 | | | | | | | × | |
| | L. ——— c. f. lepis | 204 | | | | | | | × | × |
| | L. ——— c. f. Davisii | 203 | | | | | | | | × |
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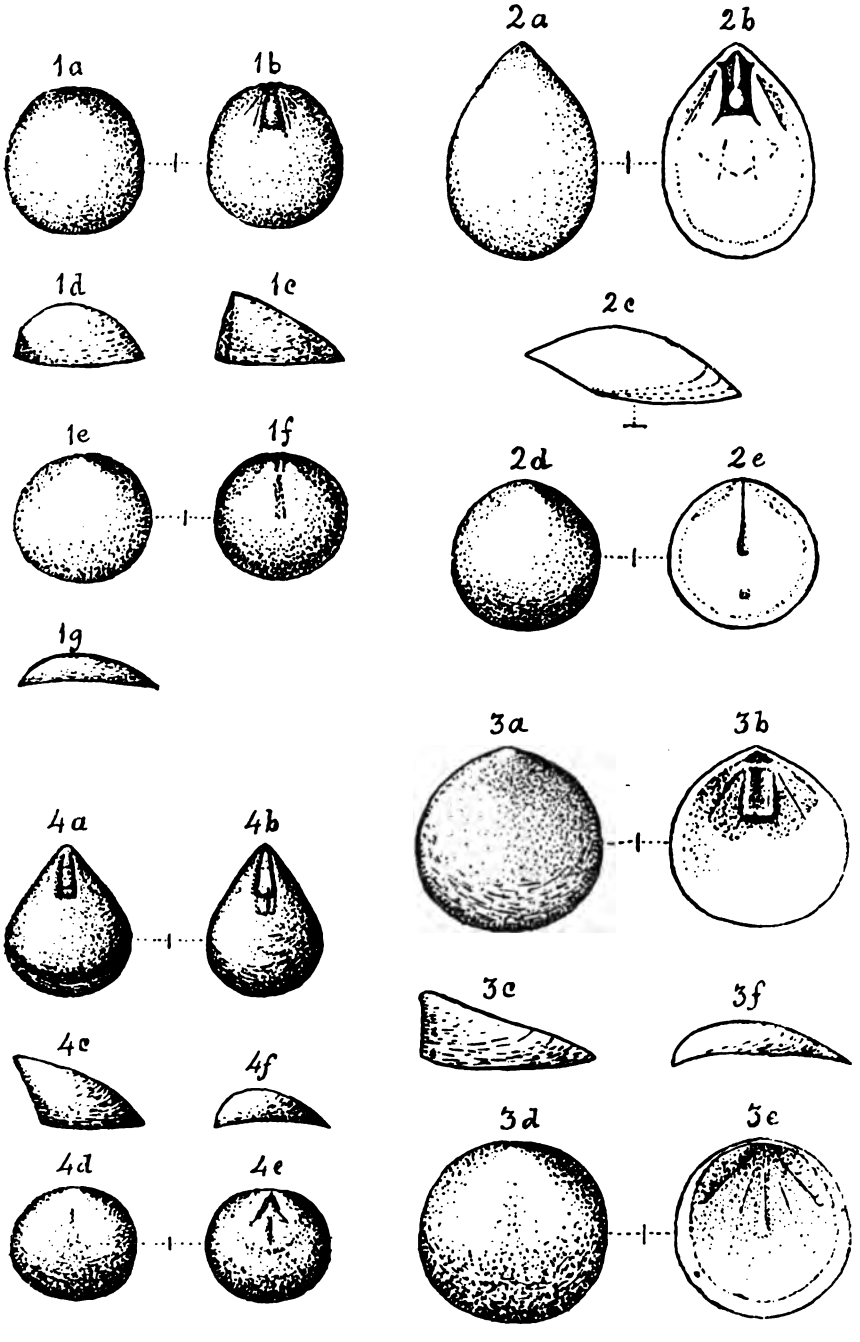
## *PLATE I.*

FIG. 1. *Acrothyra signata* mut. *prima* 2½ x 2¾ x 1¼ m. Mag. $\frac{2}{3}$; —*a* Ventral valve; —*b* Mould of interior of same; —*c* Ventral from the side; —*d* Another ventral with low umbo; —*e* Dorsal valve; —*f* Mould of the interior; —*g* Dorsal from the side. From Colbrook group at Dugald brook, Escasonie, N. S. See p. 73.

FIG. 2. *Acrothyra signata* 3 x 2 x 1 mm. Mag. $\frac{6}{1}$; —*a* Ventral valve; *b* Mould of the interior; —*c* Ventral valve from the side; —*d* Dorsal valve; *e* Mould of interior of same. From Assise E. 1*b* (Lower Etcheminian), Dugald brook, Escasonie. See p. 87.

FIG. 3. *A. signata* mut. *sera*, 2½ x 2½ x 1½. Mag. $\frac{1}{1}$; —*a* Ventral valve; —*b* Mould of interior of same; —*c* Ventral from the side; —*d* Dorsal valve; —*e* Mould of interior; —*f* Dorsal from the side. From Assise E. 1*c* (Lower Etchemin.) at Dugald brook, Escasonie, N. S. See p. 87.

FIG. 4. *A signata*, mut. *orta*, 2 x 1¾ x 1 mm. Mag. $\frac{6}{1}$; —*a* Ventral valve, mould of interior showing visceral callus; —*b* Another narrower, showing traces of extension of the callus; —*c* Ventral from the side; —*d* Dorsal valve; —*e* Mould of interior of the dorsal; —*f* Dorsal from the side. From Assise E. 2*c* (Lower Etchemin.) at Dugald brook, Escasonie, N. S. See p. 80.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## *PLATE II.*

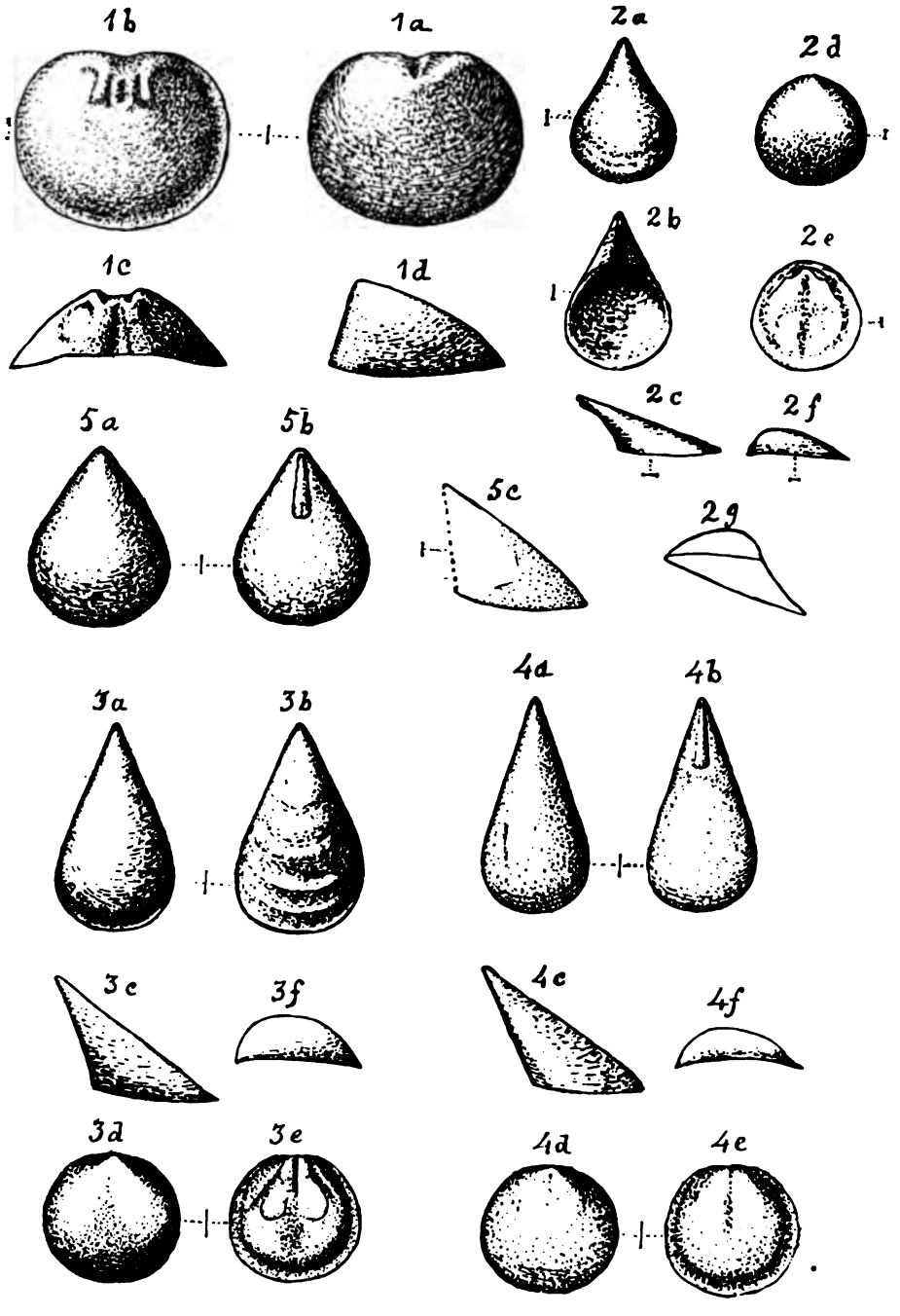
FIG. 1. *Acrothyra signata* mut. *tarda*, 2½ x 3 x 1½ mm. Mag. $\frac{1}{1}^{0}$ ; —*a* Ventral valve from above ; —*b* Mould of interior of a ventral ; —*c* Same seen from behind ; —*d* Ventral valve from the side. From Assise E. 1*d* (Lower Etchemin.) at Dugald brook, Escasonie, N. S. See p. 89.

FIG. 2. *Acrothyra proavia*, 2 x 1½ x ¾ mm. Mag. $\frac{1}{1}^{0}$ ;—*a* Ventral valve ;— *b* Same from behind ;—*c* Same from side ;—*d* Dorsal valve ;—*e* Mould of the inside of this valve ;—*f* Dorsal from the side ;—*g* Outline of the two valves, from the side. From Assise E.3*c* (Upper Etchemin.) at Dugald brook, Escasonie, N. S. See p. 90.

FIG. 3. *A. proavia*, large valves, 3 x 2¾ x ¾ mm. Mag. $\frac{1}{1}^{0}$ ;— *a* Ventral valve ;— *b* Another ventral with corrugated front ;—*c* Ventral from the side ; —*d* Dorsal ; —*e* Mould of interior of the dorsal ;—*f* Dorsal valve in profile. From Assise E 3*e*, lower part, (Upper Etchemin.) at Dugald brook, Escasonie, N. S. See p. 90.

FIG. 4. *A. proavia*, mut, *prima*, 3 x 2 x 1½ mm. Mag. $\frac{1}{1}^{0}$ :—*a* Ventral valve ;—*b* Mould of interior ·—*c* Ventral, from the side ;—*d* Dorsal valve ;—*e* Mould of interior ; —*f* Dorsal from the side. From Assise E. 3*a* (Upper Etchemin.) at Dugald brook, Escasonie, N.S. See p. 93.

FIG. 5. *A. proria*, mut. *crassa*, 2½ x 2 x 2 1½ mm. Mag. $\frac{1}{1}^{0}$ : —*a* Ventral valve ; *b* Mould of same ; —*c* Ventral from the side. From Assise E. 3*c*, lower part, (Upper Etchemin.) Dugald brook, Escasonie, N. S. See p. 94.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## *PLATE III.*

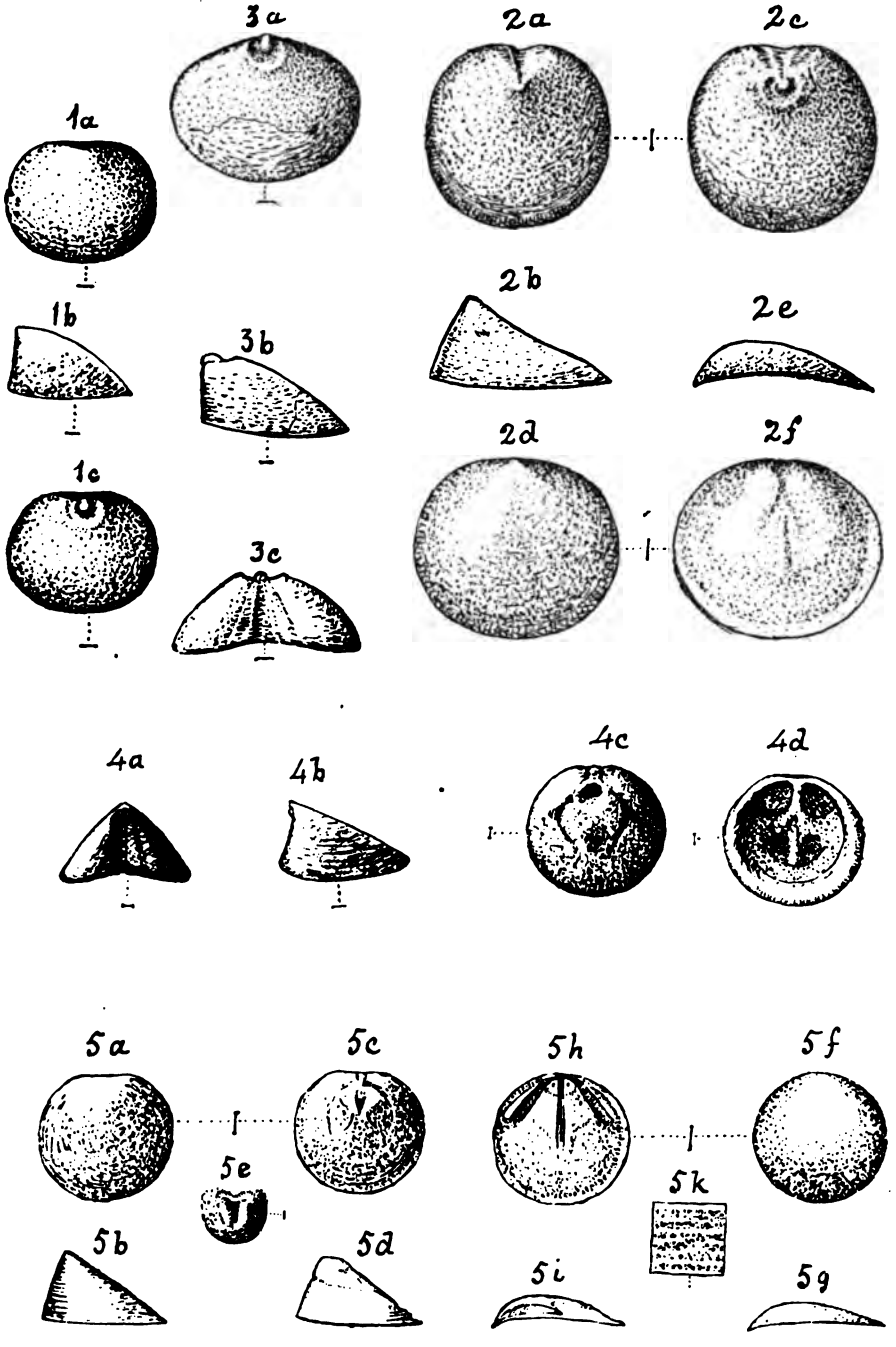
FIG. 1. *Acrotreta papillata*, 2½ x 2½ x 1¼ mm. Mag. $\frac{5}{1}$ – *a* A narrow ventral valve;—*b* Same from the side;—*c* Mould of interior of a ventral valve;—*d* Dorsal valve;—*e* Same from the side;—*f* Mould of interior. From Assise E. 1*d* (Lower Etchemin.) at Boundary brook, Escasonie, N. S. See p. 95.

FIG. 2. *papillata*, mut. *prima*, 2 x 2½ x 1¼ mm. Mag. $\frac{5}{1}$;—*a* Ventral valve;—*b* Same, side view;—*c* Mould of ventral. From the Coldbrook Group, Dugald brook, Escasonie, N.S. See p. 73.

FIG. 3. *A papillata* var. *lata*, 2 x 2½ x 1¼ mm. Mag. $\frac{10}{1}$;—*a* Ventral, mould of interior;—*b* Same from the side;—*c* Same from behind. From Assise E. 1*d* (Lower Etchemin.) at Boundary brook, Escasonie, N. S. See p. 95.

FIG. 4. *Acrotreta gemmula*, 1½ x 1½ x 1 mm. Mag. $\frac{10}{1}$;—*a* Ventral from behind;—*b* Same from the side;—*c* Ventral, mould of interior;—*d* Dorsal, interior. From Protolenus Beds (C. 1*b*), Hanford brook N. B. See p. 97.

FIG. 5. *Acrotreta* cf. *socialis*, v. Seebach 3 x 3 x 2 mm. Mag. $\frac{5}{1}$ (except *e* and *k*):—*a* Ventral valve;—*b* Same from the side;—*c* Mould of interior;—*d* Same from the side;—*e* Apex of the mould, mag. $\frac{7}{1}$;—*f* Dorsal valve;—*g* Same from the side;—*h* Mould of interior;—*i* Same from the side;—*k* Enlargement of surface sculpturing, mag. $\frac{15}{1}$. From Lingulella radula Zone, (St. John Gr. C.2*c*), McNeil brook, Mira, N. S. See p. 183.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## *PLATE IV.*

FIG. 1. *Acrotreta Baileyi*, 3½ x 4 x 1 mm. Mag. 1; —*a* Ventral, mould of interior; —*b* Same from the side; —*c* Dorsal, mould of interior; —*d* Same from the side. (C.1*d*) Lower Paradoxides Beds, Kings Co., N. B. See p. 97.

FIG. 2. *Acrotreta bisecta* 3 x 3¼ x 3½ mm. Mag. 1; —*a* Ventral valve; —*b* Mould of interior from the side; —*c* Same seen from above; —*d* Dorsal valve; —*e* Mould of interior from behind; —*f* Same from the side; —*g* Same from above. From the Dictyonema Beds, (C.3*c*) McLeod brook, Boisdale, N. S. See p. 186.

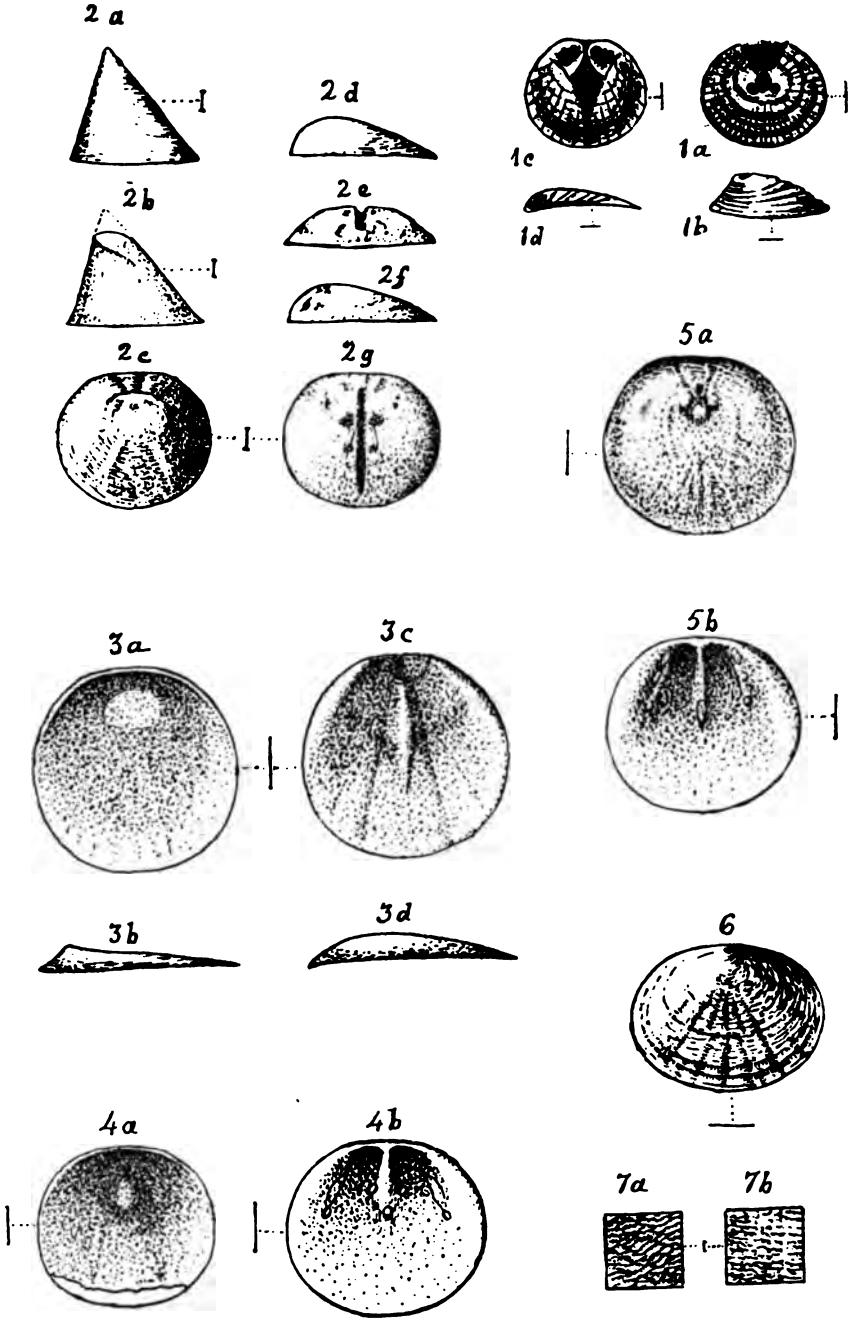
FIG. 3. *Acrothele abavia*. 6½ x 6½ x ¾ mm. Mag, 1; —*a* Ventral valve, interior, the umbo is filled with a plug of fine sand; —*b* Same from the side; —*c* Dorsal valve, interior, the shell is broken away at the umbo; —*d* Same from the side. From Assise E.3*a* (Upper Etchemin.) at Dugald Brook, Escasonie, N. S. See p. 100.

FIG. 4. *Acrothele abavia*, 5½ x 6 x 1 mm. Mag. 1; —*a* Ventral valve, interior; —*b* Dorsal valve, interior. From Assise E.3*b* (Upper Etchemin.) at Dugald brook, Escasonie, N. S. See p. 100.

FIG. 5. *Acrothele avia*, mut. *puteis*, 6 x 6½ x 1 mm. Mag. 1; —*a* Ventral valve, mould of interior; —*b* Dorsal valve, interior. From Assise E. 3*d* (Upper Etchemin), Dugald brook, Escasonie, N. S. See p. 100.

FIG. 6. *Acrothele Matthewi* var. *costata*, 5 x 6 mm. Mag. 1. From the Protolenus Beds (C. 1*b*), Hanford brook, St. John Co., N. B. See p. 104.

FIG. 7. *Acrothele avia*.—Enlarged sculpture. See Plate V.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7b

## *PLATE V.*

FIG. 1. *Acrothele avia* 9 x 10 x 1 mm. Mag. 1 (except *c.* to *f.*); —*a* Ventral valve, central part; —*b* Same seen from the side; —*c* Ventral, interior of; —*d* Dorsal valve; —*e* Same in outline; —*f* Dorsal, interior—*c.* to *f.* mag. 1. Fig. 7 of Plate IV; —*a* Surface sculpture on lateral slope of ventral; —*b* Sculpture on middle part of ventral. Both mag. 4. All from Assise E. 3*e* (Upper Etchemin) at Dugald brook, Escasonie, N. S. See p. 98.

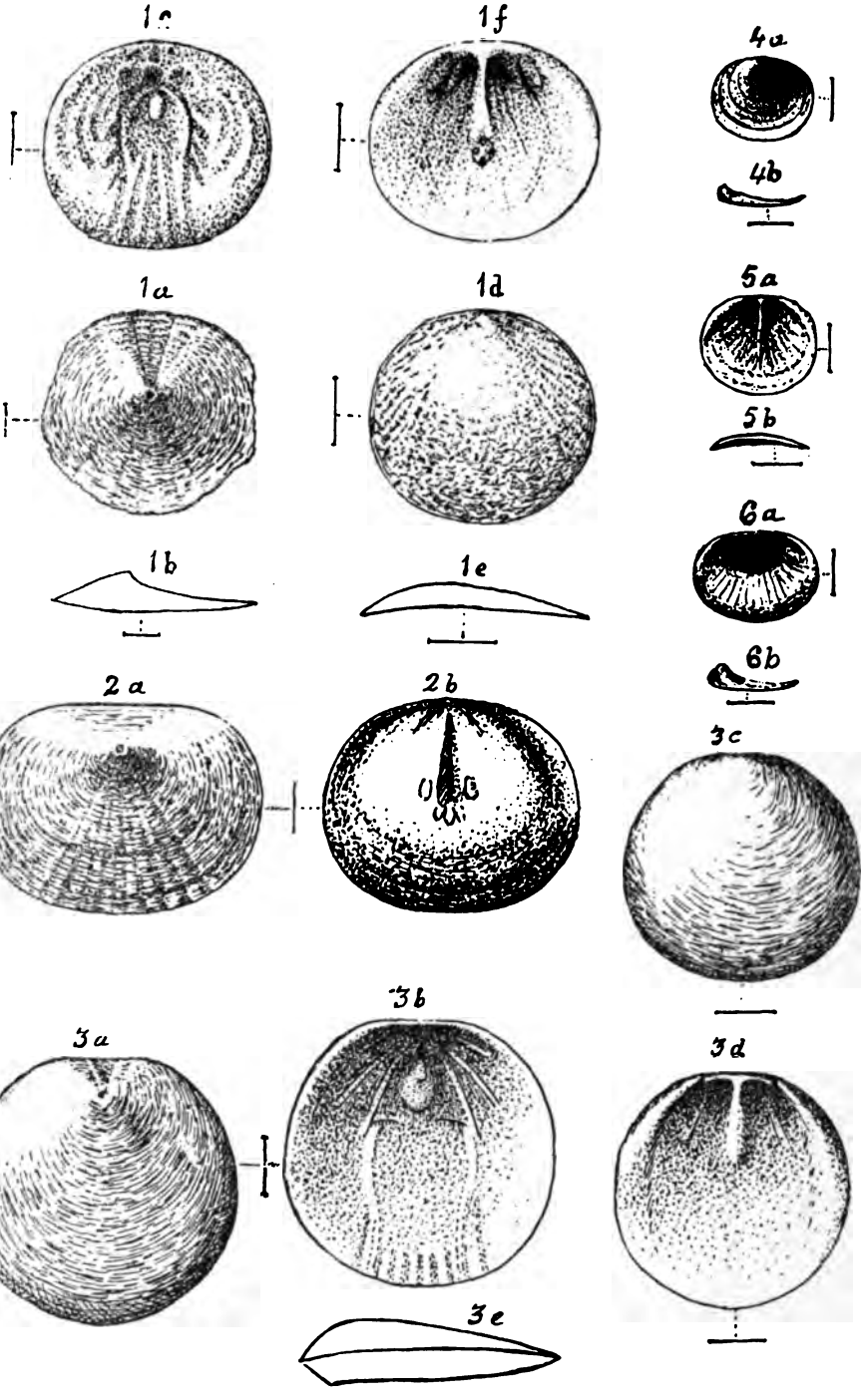
FIG. 2. *Acrothele avia*, broad form, ventral, 7 x 9½ x 1 mm. Mag. 1, Dorsal 5½ x 7 mm., mag. 1; —*a* Ventral valve; —*b* Dorsal valve, mould of interior. From Assise E. 3*d* (Upper Etchemin) at Dugald brook, Escasonie, N. S. See p. 99.

FIG. 3. *Acrothele proles* 8½ x 9 x 1 mm. Mag. 1; —*a* Ventral valve; —*b* Interior of same; —*c* A smaller dorsal valve; —*d* Interior of same; —*e* Outline of the valves from the side. From Assise E. 3*f* (Upper Etchemin.) at Gillis', Indian brook, Escasonie, N. S. See p. 102.

FIG. 4. *Acrothele Matthewi*, Hartt, mut. *prima*. Mag. 1; —*a* Ventral valve, showing the umbo close to the posterior margin; —*b* Same in profile. From Protolenus Beds (C. 1*b*), Hanford brook, N. B. See p. 104.

FIG. 5. *Acrothele Matthewi*. Mag. 1; —*a* Dorsal valve, interior, showing median septum and its branches, and fine striae on the valve radiating to the anterior and lateral margins; —*b* This valve in profile. From Lower Paradoxides Beds (C. 1*c*), Hanford brook, N. B. See p. 104.

FIG. 6. *Acrothele Matthewi* mut. *lata*. Mag. 1; —*a* Ventral valve, interior; has two pits in front of the foramen, diverging arched ridges on each side of the foramen, and a low ridge on each side of the foramen extending to the hinge line; —*b* A dorsal in profile, showing the position of the hinge line. From Protolenus Beds (C. 1*b*), Hanford brook, N. B. See p. 104.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## *PLATE VI.*

FIG. 1. *Leptobolus torrentis*, n sp. Ventral valve partly exfoliate l Mag. $\frac{6}{1}$ from Coldbrook terrane. Dugald brook, Escasonie, N. S. See p. 74.

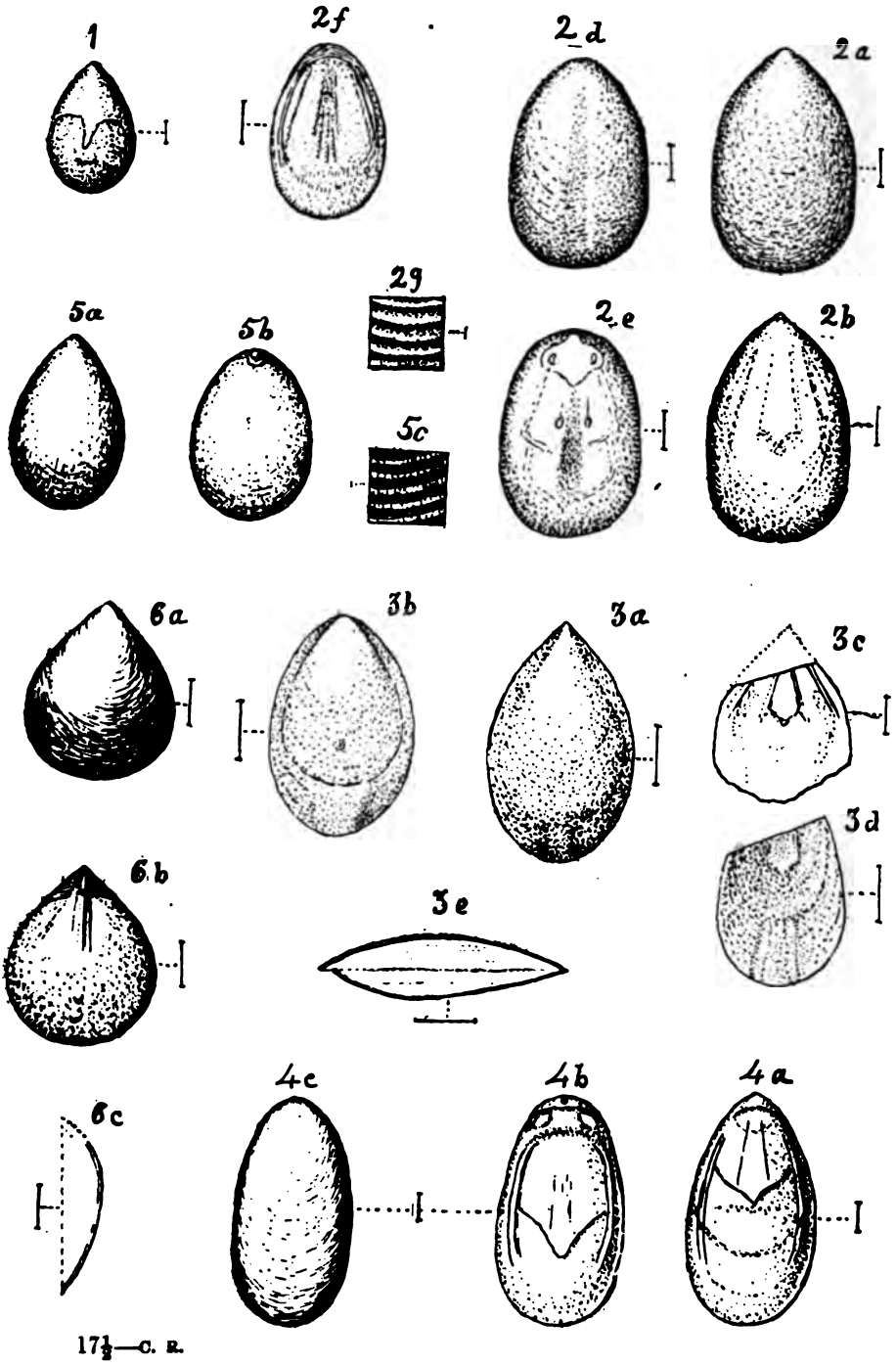
FIG. 2. *Leptobolus atavus*, *a* Ventral valve;—*b*;—Mould of interior;—*d* Dorsal valve;—*e* Mould of interior;—*f* Another showing median and lateral septa. All Mag. $\frac{6}{1}$;—*g* Portion of outer surface of the shell, Mag. $\frac{40}{1}$. From Assise E. 3*c*. Dugald brook, Escasonie, N. S. See p. 106.

FIG. 3. *Leptobolus collicia.*—*a* Ventral valve;—*b* Dorsal valve;—*c* Interior of a broken ventral valve. All Mag. $\frac{4}{1}$;—*d* Another ventral showing callus of visceral cavity:—Mag. $\frac{6}{1}$;—*e* Section of two valves, Mag. $\frac{4}{1}$. From Assise E. 3*c*. Dugald brook, Escasonie, N. S. See p. 112.

FIG. 4. *Leptobolus atavus*, mut. *insulæ*, n. mut.;—*a* Mould of interior of ventral valve;—*b* Mould of interior of dorsal valve;—*c* Dorsal valve. All Mag. $\frac{8}{1}$. From Assise E. 2 (*a*?) Young Point. See p. 110.

FIG. 5. *Leptobolus atavus*, mut. *tritavus*, n. mut;—*a* Ventral valve;—*b* Dorsal valve, exfoliated at the umbo. Both Mag. $\frac{6}{1}$;—*c* A part of the surface enlarged to show the sculpture, Mag. $\frac{30}{1}$;—From Assise E. 1*d*. Boundary brook Escasonie, N. S. See p. 109.

FIG. 6. *Lingulella tumida*;—*a* Ventral valve;—*b* Mould of interior;—*c* Longitudinal section. All Mag. $\frac{4}{1}$;—From Assise E. 3*c*. Dugald brook Escasonie, N. S. See p. 123.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## *PLATE VII.*

FIG. 1.—***Lingulella Selwyni.***—*a*, mould of interior of ventral valve.—*b*. mould of interior of dorsal valve. Both Mag. $\frac{2}{1}$—*c*. Visceral and lateral areas, Mag. $\frac{4}{1}$ to show the muscle scars, vascular trunks, and hinge area. From Assise E. 2 (*a* ?) at Young point, George river, N. S. See p. 116.

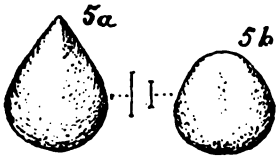
FIG. 2.—***Lingulella*** cf. ***longovalis.*** Dorsal valve, umbo broken, Mag. $\frac{3}{1}$. From the Coldbrook terrane at Dugald brook, Escasonie, N. S. See p. 75.

FIG. 3.—***Lingulella longovalis***, n sp—*a*, Ventral valve, partly exfoliated.—*b*. The same valve, mould of.—*c*, dorsal valve.—*d*. mould of the dorsal.—*e*. section of the two valves. All Mag. $\frac{3}{1}$.—*f*. A portion of the surface of the shell Mag. $\frac{10}{1}$ to show the sculpture. All from Assise E. 1 *c*. Dugald brook, Escasonie N. S. See p. 123.

FIG. 4.—***Obolus lens***, var. ***longus***, n. var.—*a*, Ventral valve mostly exfoliated—*b*. Dorsal valve. Both Mag. $\frac{2}{1}$. From Assise E. 3 e. Dugald brook, Escasonie, N. S. See p. 146.

FIG. 5.—***Lingulepis pumila*** n sp.—*a*, Ventral valve. Mag. $\frac{4}{1}$—*b*, Dorsal valve mag. $\frac{4}{1}$. Both from the Coldbrook terrane, Dugald brook, Escasonie, N. S.—See p. 75.

FIG. 6.—***Lingulepis longinervis***, n sp.—*a* Ventral valve—*b*. Mould of the same. Both mag. $\frac{2}{1}$—*c*, Cardinal area of this valve. Mag. $\frac{1}{1}$, —*d*, Longitudinal section of this valve—*e*, Dorsal valve partly exfoliated. Both mag. $\frac{2}{1}$—*f*. Interior of a small dorsal Mag. $\frac{4}{1}$—*g*. Longitudinal section of the same. All from Assise E. 2 *b*. Dugald brook, Escasonie, N. S. See p. 133.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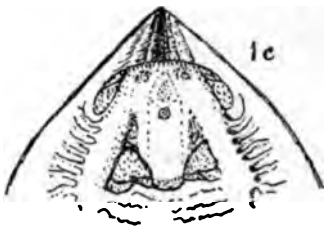
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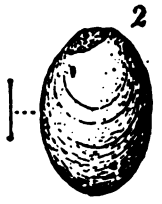
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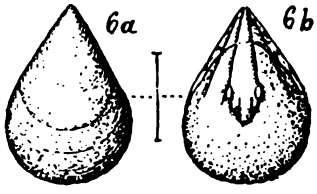
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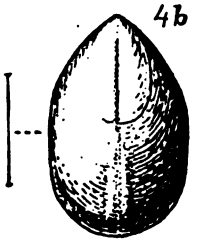
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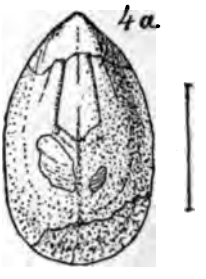
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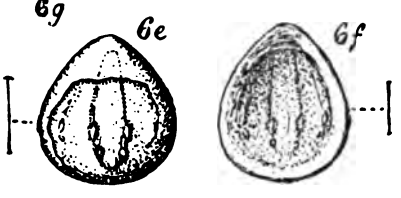
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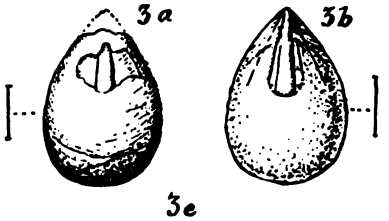
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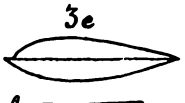
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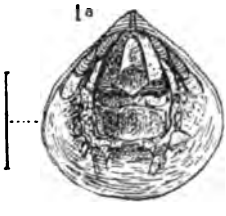
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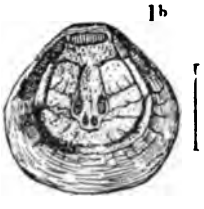
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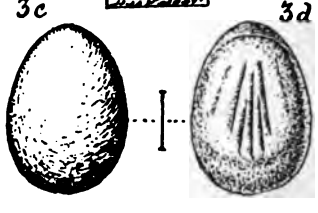
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## *PLATE VIII.*

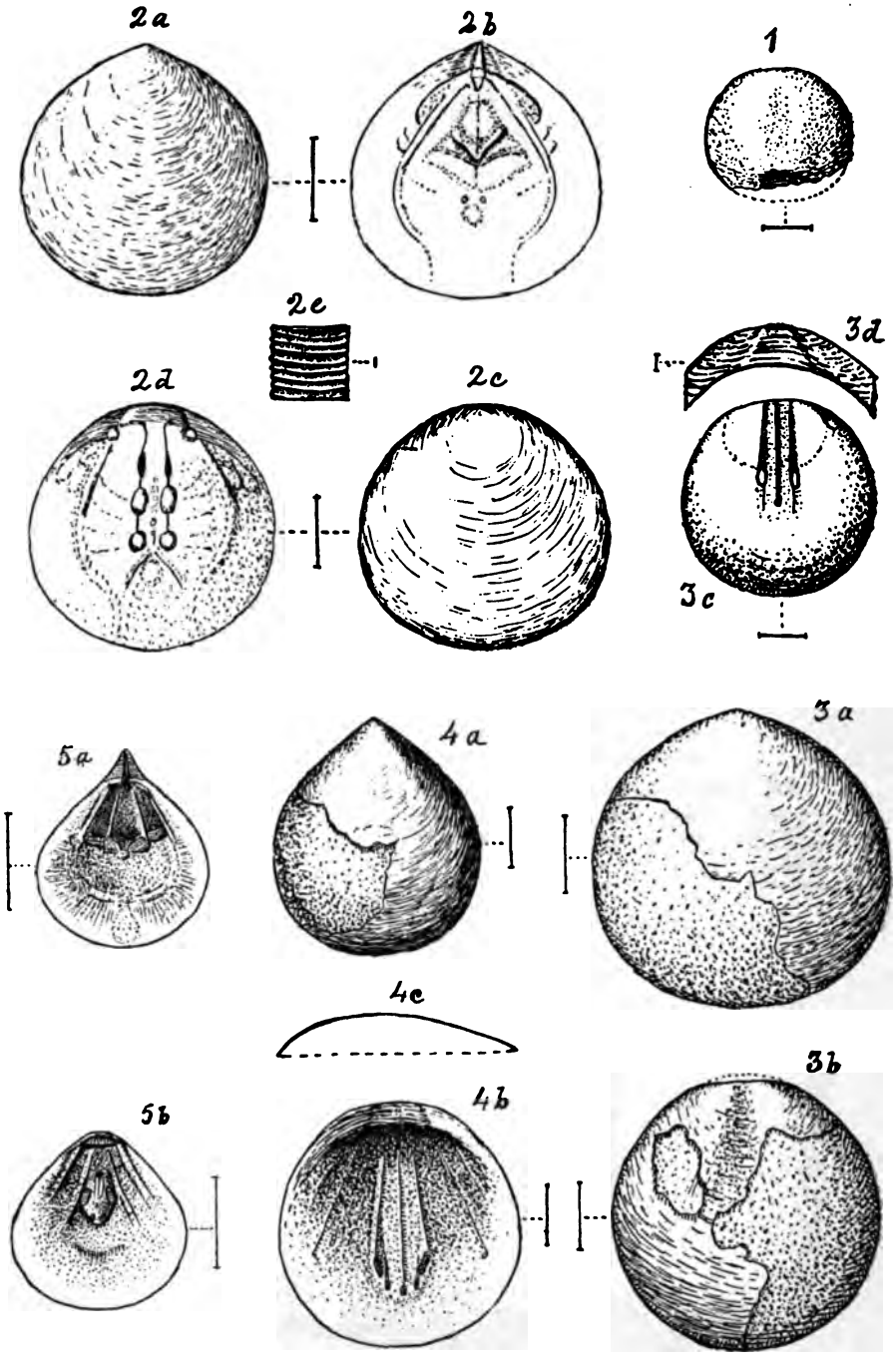
FIG. 1. *Obolus torrentis* n. sp.—Dorsal, crushed in front. Mag $\frac{3}{4}$. From Coldbrook terrane, Dugald brook, Escasonie N. S. See p. 76.

FIG. 2. *Obolus æquiputeis*, n. sp.—*a* Ventral valve ; —*b* Interior of ventral, both Mag. $\frac{3}{4}$ ; —*c* Dorsal valve ; —*d* Mould of interior of same. Both Mag. $\frac{3}{4}$ ;—*e* Portion of the surface of a valve, Mag. $\frac{1}{1}^{0}$. All from Assise E. 2 (*a*?) Young point, George river, N. S. See p. 139.

FIG. 3. *Obolus discus*, n. sp.—*a* Ventral valve, partly exfoliated ; —*b* Dorsal valve, exfoliated ; —*c* Mould of a dorsal valve. The three Mag. $\frac{3}{4}$ ; —*d* Hinge area of the dorsal. Mag. $\frac{1}{1}$. All from Assise E 1*c* Dugald brook, Escasonie, N. S. See p. 138.

FIG. 4. *Obolus triparilis*, n. sp.—*a* Ventral valve exfoliated ; —*b* Interior of dorsal valve; —*c* Section, longitudinal, of ventral valve. All Mag. $\frac{1}{1}$. From Assises E. 1*b* and *c* Dugald brook, Escasonie, N. S. (See also next plate). See p. 136.

FIG. 5. *Lingulepis Roberti*—*a* Interior of ventral valve ; —*b* Interior of dorsal valve. Both Mag. $\frac{3}{4}$. From Assise E. 2 (*a*?) Young point, George river, N. S. See p. 132.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4b

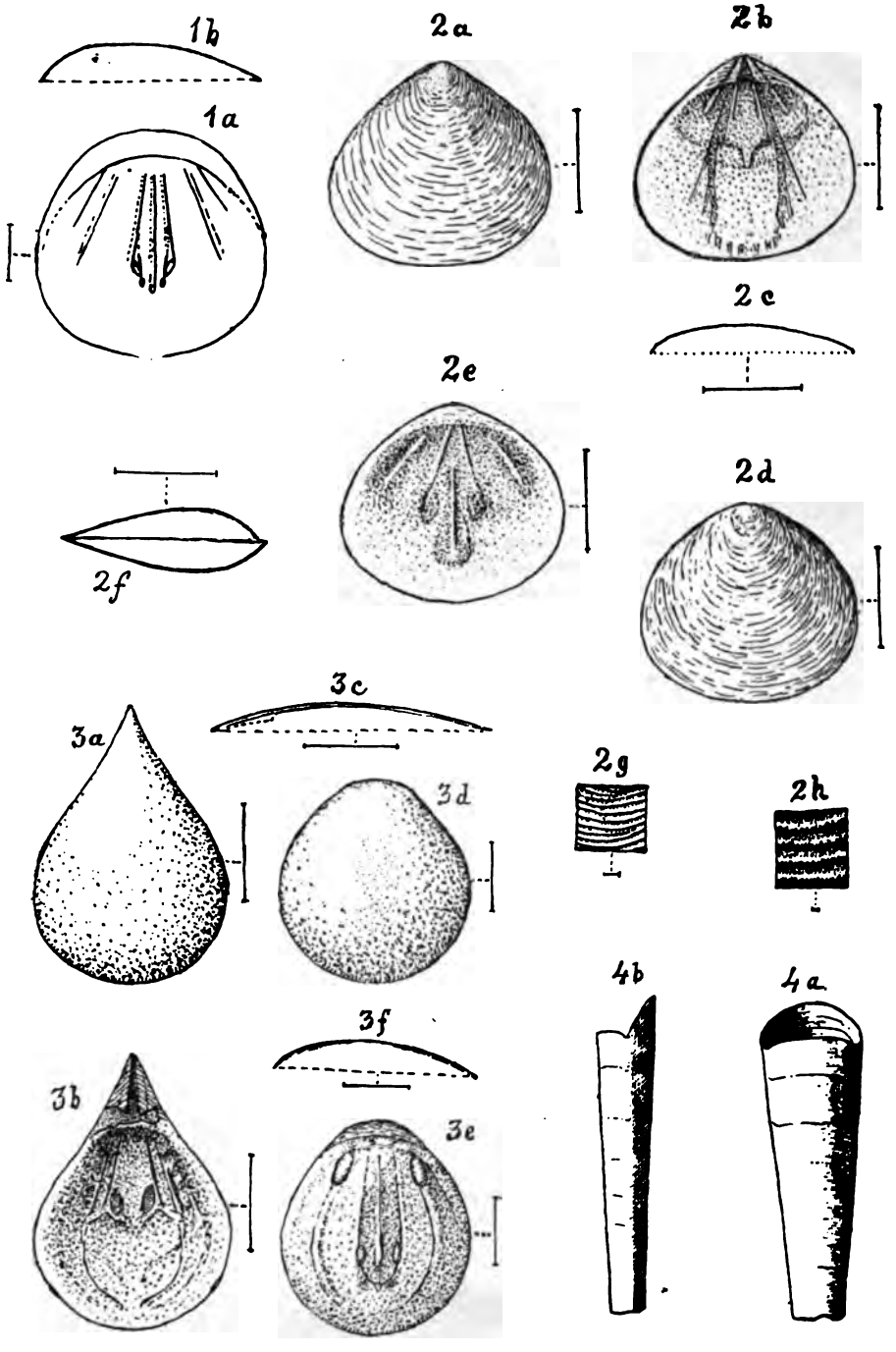
## *PLATE IX.*

FIG. 1. *Obolus triparilis*, n. sp.—*a* Mould of the dorsal valve; —*b* Longitudinal section of this valve. Both Mag. $\frac{4}{1}$. From Assise E. 1*b* Dugald brook, Escasonie N. S. See p. 136.

FIG. 2. *Obolus Bretonensis*—*a* Ventral valve; —*b* Interior of same; —*c* Longitudinal section of same; —*d* Dorsal valve; —*e* Interior of same; —*f* Longitudinal section of the two valves. All mag. $\frac{2}{1}$. *g* Portion of the surface enlarged to show sculpture, Mag. $\frac{4}{1}$; —*h* a portion further enlarged. Mag. $\frac{10}{1}$. From Assise E. 3*d*. Dugald brook, Escasonie, N. S. See p. 141.

FIG. 3.—*Lingulepis Greŋwa*—*a*, ventral valve, *b*, interior of the same,—*c*, Longitudinal section of the same—*d*, dorsal valve,—*e*, mould of the same,—*f*, Longitudinal section of the same. All mag. $\frac{2}{1}$. From Assise E. 1 *d*. Dugald brook, Escasonie, N. S. See p. 126.

FIG. 4.—*Hyolithes* cf. *tenuistriatus* (and cf. *princeps*)—*a*, Tube, from the ventral face—*b*, same from the left side. Mag. $\frac{2}{1}$. From Assise E. 2? (a?) Young point, George river, N. S. See p. 83.


1b
1a
2a
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2d
3c
3a
3d
2g
2h
4b
4a
3f
3b
3e

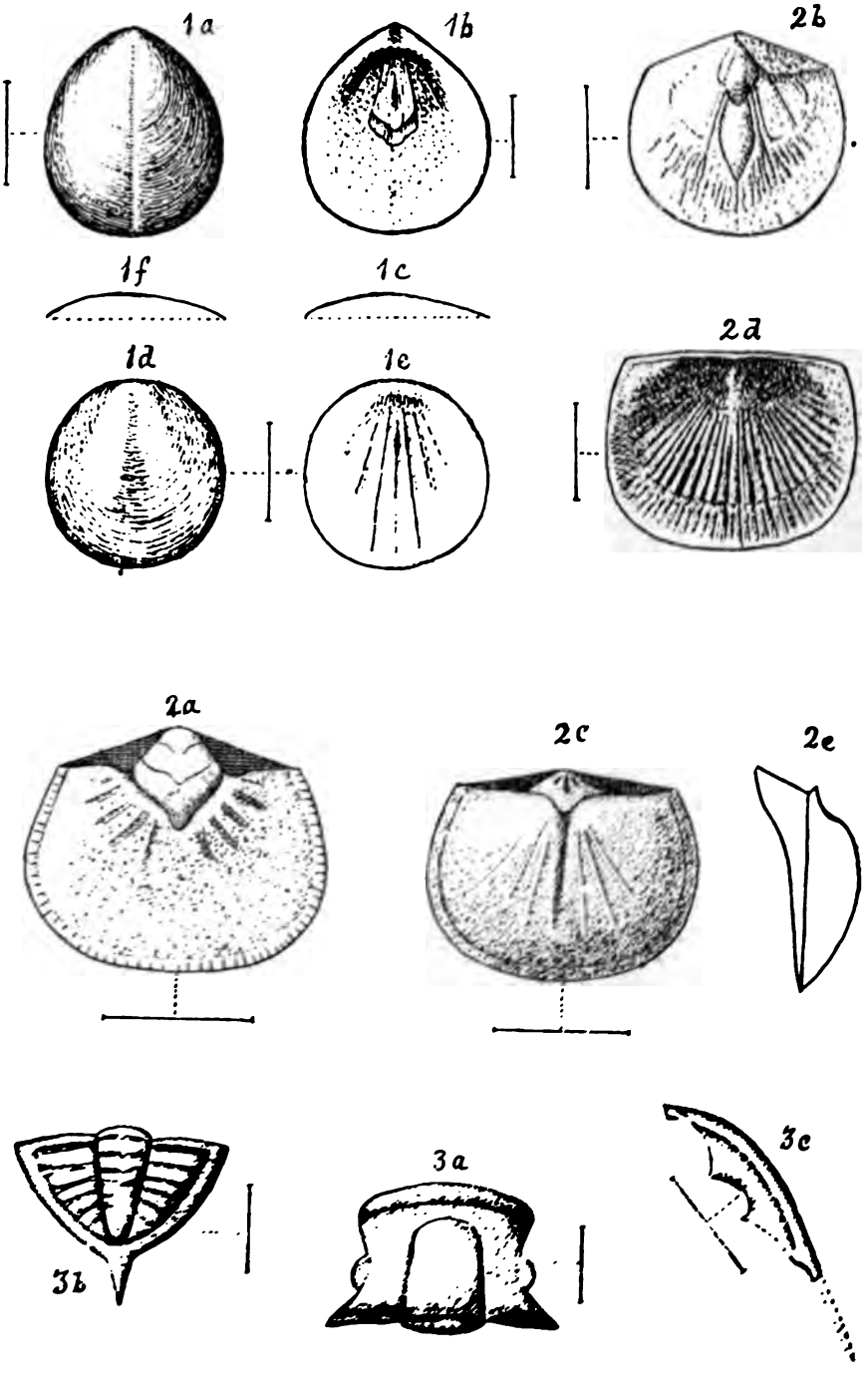
## *PLATE X.*

FIG. 1.—***Obolus lens.***—*a*, ventral valve—*b*, interior of same,—*c*, longitudinal section of same,—*d*, dorsal valve,— *e*, interior of same,—*f*, longitudinal section of same. All Mag. $\frac{2}{3}$, except fig. 1 *b*, which is enlarged $\frac{2}{1}\frac{0}{5}$. All from Assise E. 3 *c* at Dugald brook, Escasonie. See p. 144.

*O.——— lens*, var. *longus*, n. var. See pl. vii, fig. 4. See p. 146.

FIG. 2.—***Billingsella retroflexa***—*a*, mould of ventral valve—*b*, another mould narrowed by pressure, showing vascular trunks—*c*, mould of the dorsal valve—*d*, mould of the exterior of the dorsal—*e*, longitudinal section of both valves. All Mag. $\frac{2}{3}$. From Assise E. 2 (*a*?) Young point, George river, Escasonie, N. S. See p. 148.

FIG. 3. ***Holasaphus centropyge.***—*a* middle piece of the head shield ; —*b* Pygidium ; — *c* Movable cheek. All Mag. $\frac{2}{3}$. From Assise E 2 (*a*?) at Young point, George river, N. S. See p. 174.


1a
1b
2b
1f
1c
1d
1e
2d
2a
2c
2e
3b
3a
3c

## *PLATE XI.*

FIG 1. *Paradoxidoid trilobite.*—Fragment of the glabella ;—*b* Part of movable cheek ; —*c* Pygidium ; —*d* A posterior pleura ; —*e* Ring of the thorax. All natural size. From Assise E. 2 (*a f*) Young point, George river, N. S. See p. 176.

FIG. 2. *Solenopleura Bretonensis* n sp.—*a* Middle piece of the head ; —*b* Supposed movable cheek ; —*c* A pleura. All Mag. $\frac{3}{4}$. From Assise E. 3. *f*. The head from Gillis-Indian brook, the cheek and pleura from Dugald brook, Escasonie, N. S. See p. 176.

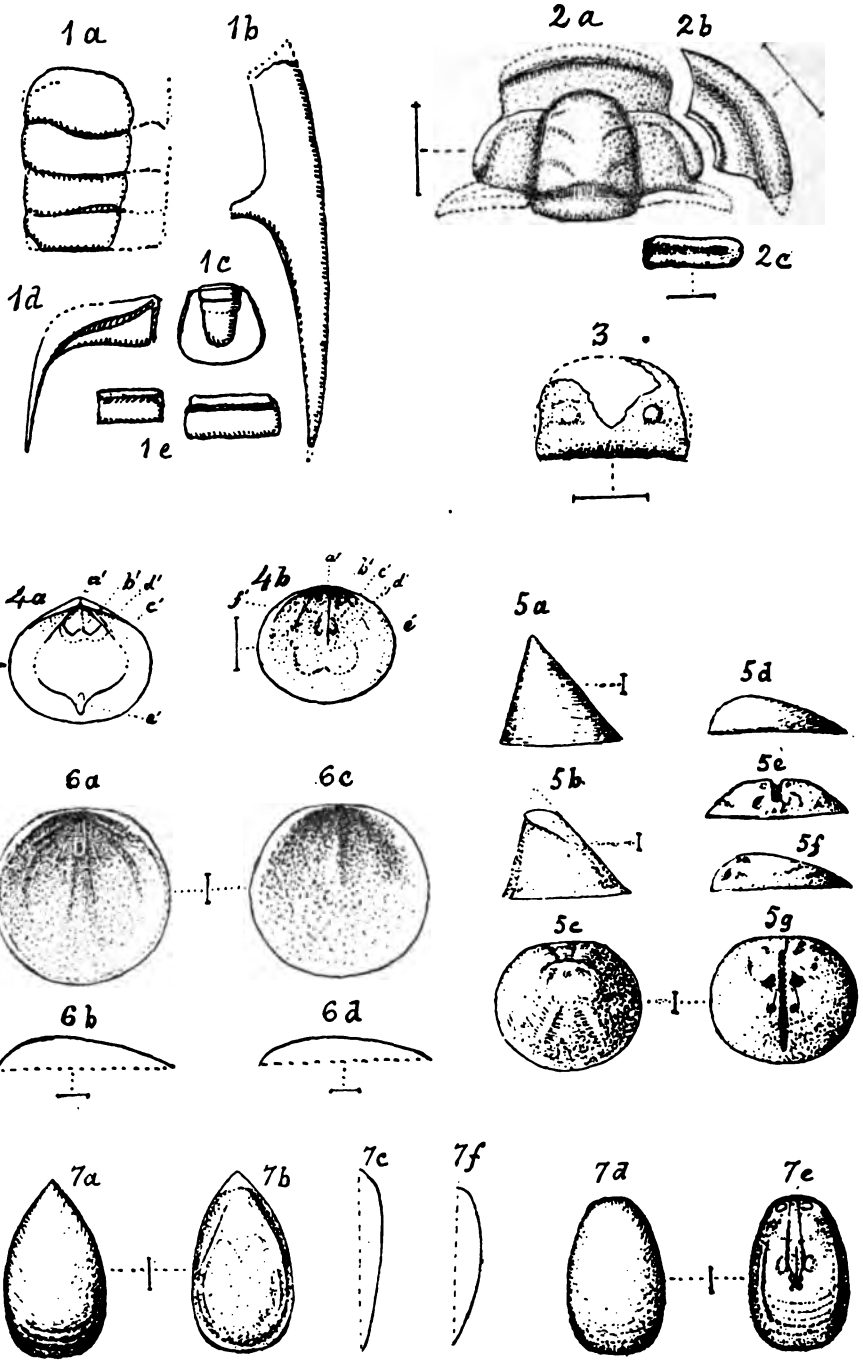
FIG. 3.—*Eurypteroid crustacean?* Carapace abraded in front. Mag. $\frac{3}{4}$. From Assise E. 3 f. Gillis-Indian brook, Escasonie, N. S. See p. 177.

FIG. 4.—*Monobolina refulgens*—a Interior of ventral valve—Legend—$a^1$ Pedicle groove— $b^1$ Anterior adductor—$c^1$ Traces of vascular trunks—$d^1$ Lateral septum—$e^1$ Mesian scar. Mag $\frac{3}{4}$. b. Interior of dorsal valve—Legend —$a^1$ Cardinal line—$b^1$ Posterior adductor—$c^1$ Anterior adductor $d^1$ Lateral septum—$e^1$ Place of anterior lateral—$f^1$ medium septum. Mag. $\frac{3}{4}$. From Navy island, St. John, N. B. Band C. 3 *c*. (See also Pl. xvi, fig. 2.) See p. 210.

FIG. 5.—*Acrotreta bisecta*—*a* Ventral valve, side view—*b*, Mould of interior of this valve —*c*, Mould seen from above—*d*, Dorsal valve *e*, Mould of interior of same, seen from behind—*f*, Same seen from the side—*g*, Same seen from above. All Mag. $\frac{4}{3}$. From Band C. 3*c*, McLeod brook, Boisdale, N. S. See p. 186.

FIG. 6. *Schizambon priscus* ; —*a* Interior of ventral valve ; —*b* Longitudinal section ; —*c* Interior of the dorsal valve ; —*d* Longitudinal section. All Mag. $\frac{3}{4}$. From Band C 3*c*. McLeod brook, Boisdale, N. S. See p. 187.

FIG. 7. *Leptobolus flumenis*, n sp ; —*a* Ventral valve ; —*b* Mould of interior of same ; *c* Longitudinal section of same ; —*d* Dorsal valve ; *e* Mould of interior of same ; —*f* Longitudinal section of same ; Band C 2. *e* McNeill brook, Miramichi river N. S. See p. 189.


1a
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1d
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3
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4b
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5e
5f
5g
6a
6b
6c
6d
7a
7b
7c
7f
7d
7e

## *PLATE XII.*

FIGS. 1 to 6.—Diagrammatic figures of genera to show important character referred to in the text—*o*, ocular tubercle—*m*, scar of adductor muscle—*c*, cardinal or hinge line—*a*, anterior cardinal curve—*b*, posterior cardinal curve—*e*, anterior marginal curve—*d*, posterior marginal curve—*v*. ventral margin. See p. 154.

FIG. 7. *Leperditia* (??) *rugosa.*—*a*, right valve, side view—*b*, same from the front—*c*, same from the hinge. All Mag. 1, Assise E. 3. *f.* Gillis—Indian brook, Escasonie, N. S. See p. 155.

FIG. 8. *Bradorona perspicator.*—*a*, left valve, side view—*b*, same from behind—*c*, same from the hinge. All mag. 1—*d*, a portion of the shell further mag. 4. Assise E. 1. *d.* Dugald brook, Escasoni, N. S. See p. 156.

FIG. 9. *B. perspicator*, mut. *maxima.*—*a*, right valve, side view—*b*, same from the front. Both Mag. 1, Assise E. 1 *c.* Dugald brook, Escasonie, N. S. See p. 157.

FIG. 10. *B. perspicator*, mut. *major.*—*a*, right valve, side view—*b*, same from the front. Both Mag. 1, Assise E. 3. *f.* Gillis—Indian brook, Escasonie, N. S. See p. 158.

FIG. 11. *B. perspicator*, mut. *magna.*—*a*, right valve, side view—*b*, same from the front. Both Mag. 1, Assise E. 2 *b.* Dugald brook, Escasonie, N. S. See p. 158.

FIG. 12. *Bradorona spectator.*—*a*, left valve, side view—*b*, same from the front—*c*, same from the hinge—*d*, mould of the upper front corner of a right valve showing ocular tubercle and muscle scar. All Mag. 1, Assises E. 1 *c.* and *d.* Dugald brook, Escasonie, N. S. See p. 158.

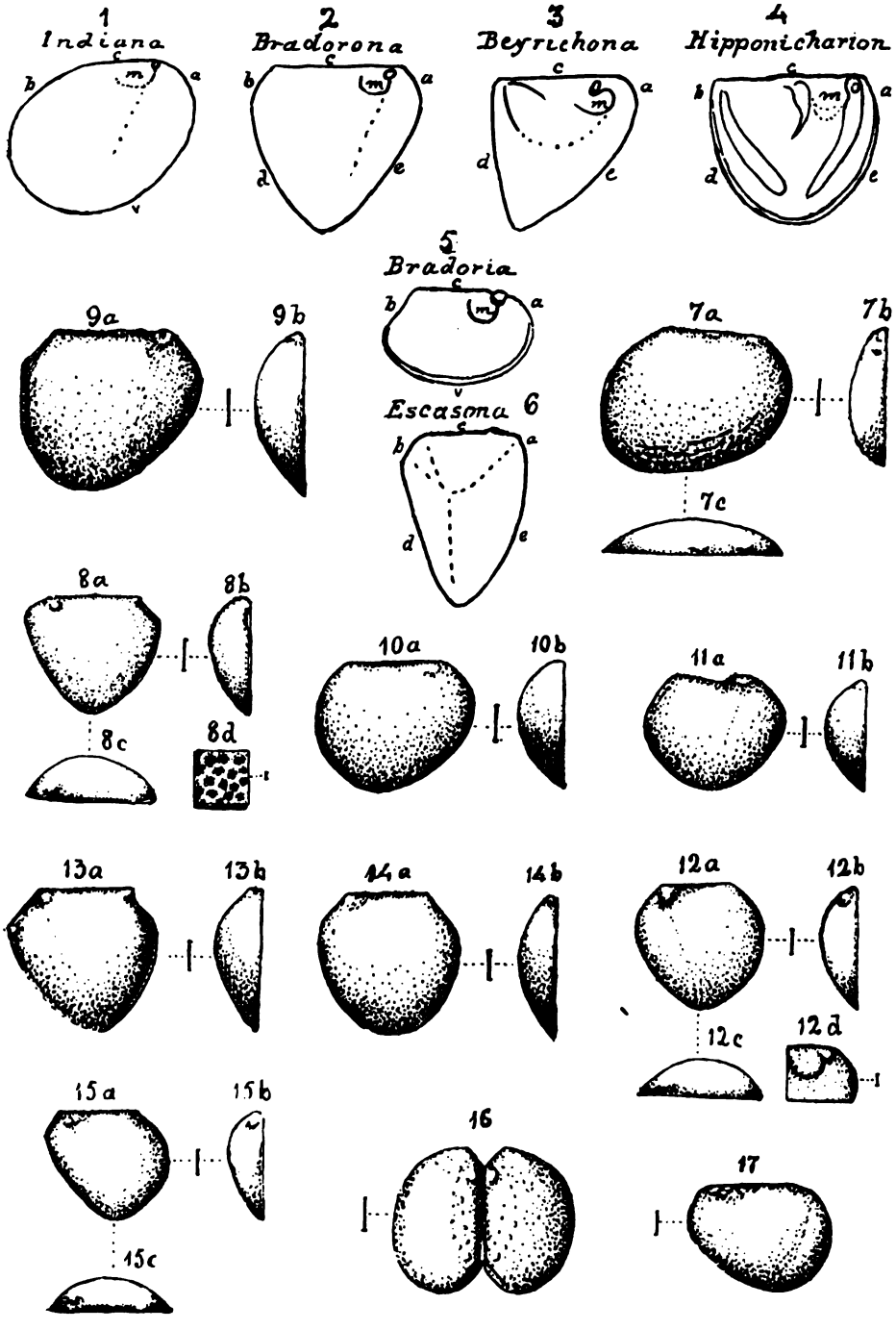
FIG. 13. *B. spectator*, mut. *spinosa.*—*a*, left valve, side view—*b*, same from the front. Both Mag. 1. Assise E. 1 *c.* Dugald brook, Escasonie, N. S. See p. 159.

FIG. 14. *B. spectator*, mut. *æquata.*—*a*, left valve, side view—*b*, same front view. Both mag. 1. Assise E. 3 *d.* Dugald brook, Escasonie, N. S. See p. 160.

FIG. 15. *Bradorona observator.*—*a*, left valve—*b*, same from the front—*c*, same from the hinge. All Mag. 1. Assise E. 1 *d.* Dugald brook, Escasonie, N. S. See p. 160.

FIG. 16. *B. observator* var. *benepuncta.*—Carapace partly opened, the valves laterally foreshortened. Mag. 1. Assise E. 1 *d.* Dugald brook, Escasonie, N. S. See p. 161.

FIG. 17. *B. observator* mut. *ligata.*—Left valve, side view. Assise E. 3 *e.* Dugald brook, Escasonie, N. S. See p. 162.


1
Indiana
2
Bradorona
3
Beyrichona
4
Hipponicharion
5
Bradoria
Escasona 6
9a
9b
7a
7b
7c
8a
8b
8c
8d
10a
10b
11a
11b
13a
13b
14a
14b
12a
12b
12c
12d
15a
15b
15c
16
17

## *PLATE XIII.*

FIG. 1.—***Bradoria scrutator***—*a*, left valve, side view—*b*, transverse section—*c*, longitudinal section. All Mag. $\frac{8}{1}$. Assise E 3 *e* and *f*, Dugald brook, Escasonie, N. S. See p. 163.

FIG. 2.—***Bradoria vigilans***—*a*, right valve, side view—*b*, outline from front—*c*, outline from the hinge. All Mag. $\frac{8}{1}$, Assise E 3 *e*. Dugald brook, Escasonie, N. S. N.B.—The ocular tubercle is too near the hinge line in figs. 2 *b* and 2 *a*.—See p. 164.

FIG. 3.—***Bradoria rugulosa***—*a*, right valve, side view—*b*, outline from front—*c*, outline from hinge line. All Mag. $\frac{8}{1}$—d, part of the shell further enlarged ($\frac{1}{1}^{0}$) to show sculpture. Assise E 3 *e*. Dugald brook, Escasonie, N. S. See p. 166.

FIG. 4. ***Bradoria*** ? ***ornata***, n. sp.—*a*, right valve, side view—*b*, outline from the front—*c*, outline from the hinge. All Mag. $\frac{8}{1}$. Assise E. 1 *c*. Dugald brook, Escasonie, N. S. See p. 166.

FIG. 5.—***Escasona rutellum***, n. sp.—*a*, right (?) valve, side view—*b*, same front view—*c*, same from the hinge. All Mag. $\frac{8}{1}$. Assise E. 3 *f*. Gillis—Indian brook. Escasonie, N. S. See p. 167.

FIG. 6.—***Escasona*** ? ***vetus***, n. sp.—*a*, right (?) valve—*b*, same from the hinge. Both Mag. $\frac{8}{1}$. Assise E. 1 *d*. Dugald brook, Escasonie, N. S. See p. 168.

FIG. 7.—***Escasona*** (??) ***ingens***, n. sp.—*a*, left (?) valve—*b*, same from the front—*c*, same from the hinge. All Mag. $\frac{4}{1}$. Coldbrook terrane. See p. 168.

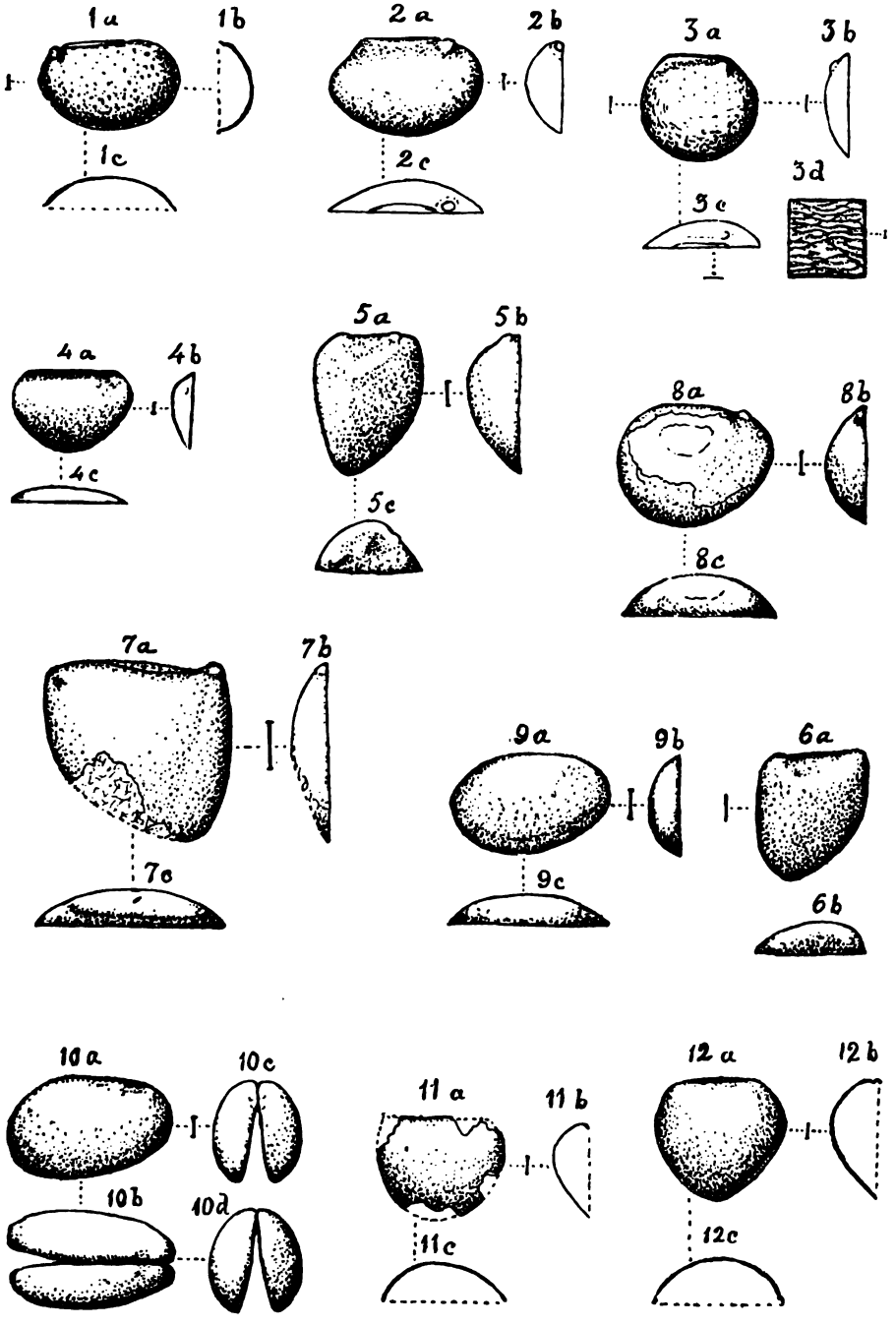
FIG. 8.—***Indiana ovalis***, n. sp.—*a*, right valve, side view—*b*, same from the front—*c*, same from the hinge. All Mag. $\frac{8}{1}$. Assises E. 1. *c* and 3 *c*. Dugald brook, Escasonie, N. S. See p. 170.

FIG. 9.—***I. ovalis*** mut ***prima***, n. mut.—*a*, right valve, side view—*b*, same from the front—*c*, same from the hinge. All Mag. $\frac{4}{1}$. Coldbrook terrane. See p. 171.

FIG. 10.—***Indiana lippa***, n. sp.—*a*, carapace, right side—*b*, same from the hinge—*c*, same from the front—*d*, same from behind. All Mag. $\frac{4}{1}$. Assise E. 3 *f*. Dugald brook, Escasonie, N. S. See p. 171.

FIG. 11. ***Schmidtella*** (?) ***pervetus***—*a*, right (?) valve, side view—*b*, transverse section—*c*, longitudinal section. All Mag. $\frac{6}{1}$. Assise E. 3 *c*. Dugald brook, Escasonie, N. S. See p. 172.

FIG. 12.—***Schmidtella acuta***—*a*, right (?) valve, side view—*b*, transverse section—*c*, longitudinal section. All Mag. $\frac{8}{1}$. Assise E. 3 *c*. Dugald brook, Escasonie, N. S. See p. 173.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7a
7b
7c
9a
9b
9c
6a
6b
10a
10c
10b
10d
11a
11b
11c
12a
12b
12c

## *PLATE XIV.*

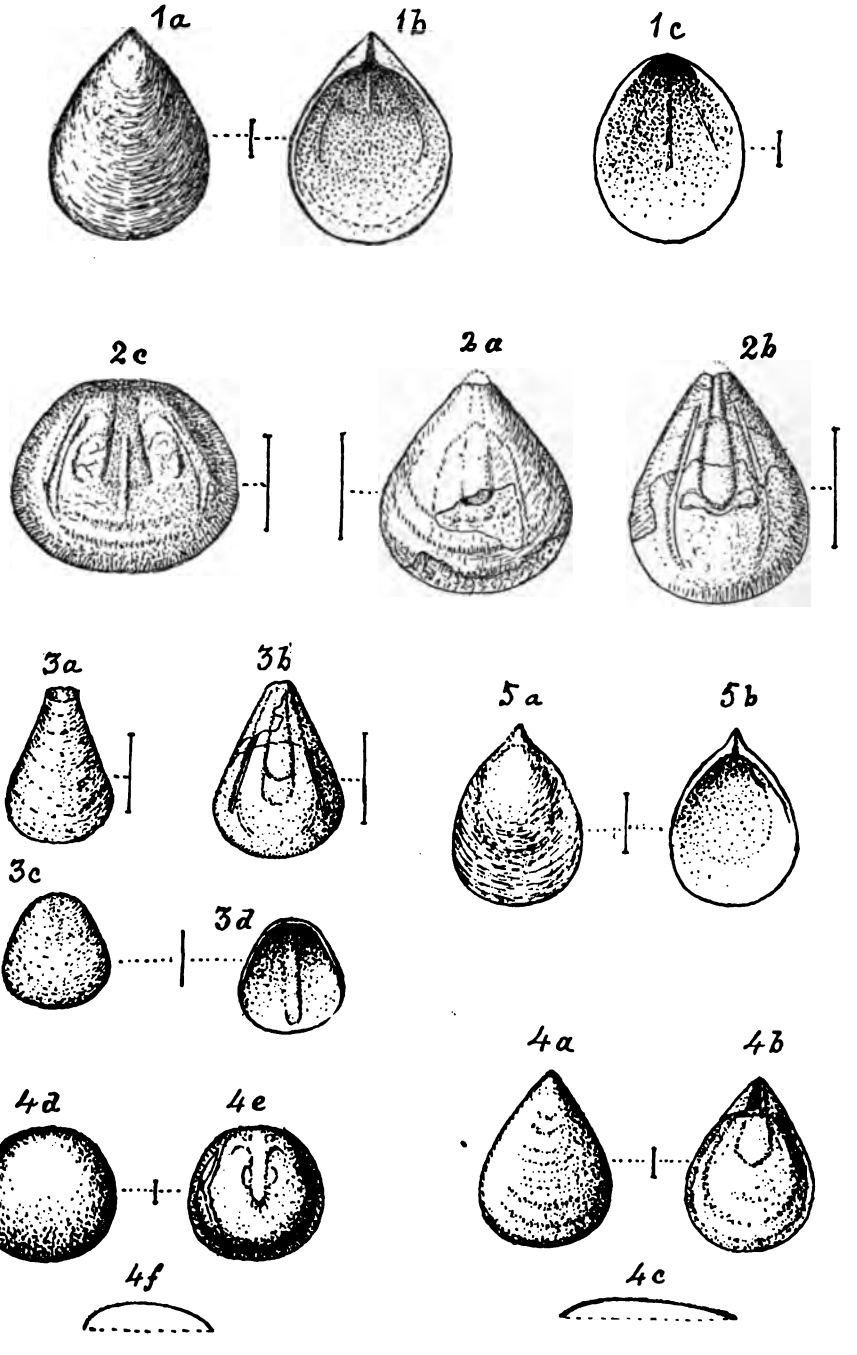
FIG. 1. *Leptobolus gemmulus.*—*a* Ventral valve- *b* Interior of same—c Interior of dorsal valve. All Mag $\frac{4}{1}$. From Band C 3 *c*. McLeod brook, Boisdale, N. S. See p. 190.

FIG. 2. *Lingulepis Starri* var.—*a* Ventral valve partly exfoliated ; —*b* Mould of interior of same, partly uncovered ; —*c* Mould of the dorsal valve. All Mag. $\frac{2}{1}$. From Band C 2*b*. McLean brook, Mira river, N. S. See 193.

FIG. 3. *Lingulepis Starri* var. *exigua* n. var. ; —*a* Ventral valve, beak broken ; —*b* Mould of interior, partly uncovered ; —*c* Dorsal valve ; —*d* Interior of same. All Mag. $\frac{2}{1}$. From Band C 2*a* at McLean brook, Mira river, N. S. See p. 197.

FIG. 4. *Lingulepis rotunda.* n. sp.—*a* Ventral valve ; —*b* mould of interior of same ; —*c* Longitudinal section of same ; —*d* Dorsal valve ; —*e* Interior of same ; —*f* Longitudinal section of same. All Mag. $\frac{4}{1}$. From Band C 3*c*. McNeill brook, Mira river, N. S. See p. 199.

FIG. 5. *Lingulella concinna.*—*a* Ventral valve ; —*b* Interior of same. Both Mag. $\frac{3}{1}$. From Band C 3*c*, McLeod brook, Boisdale, N. S. See p. 203.


1a
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3b
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3d
5a
5b
4a
4b
4d
4e
4f
4c

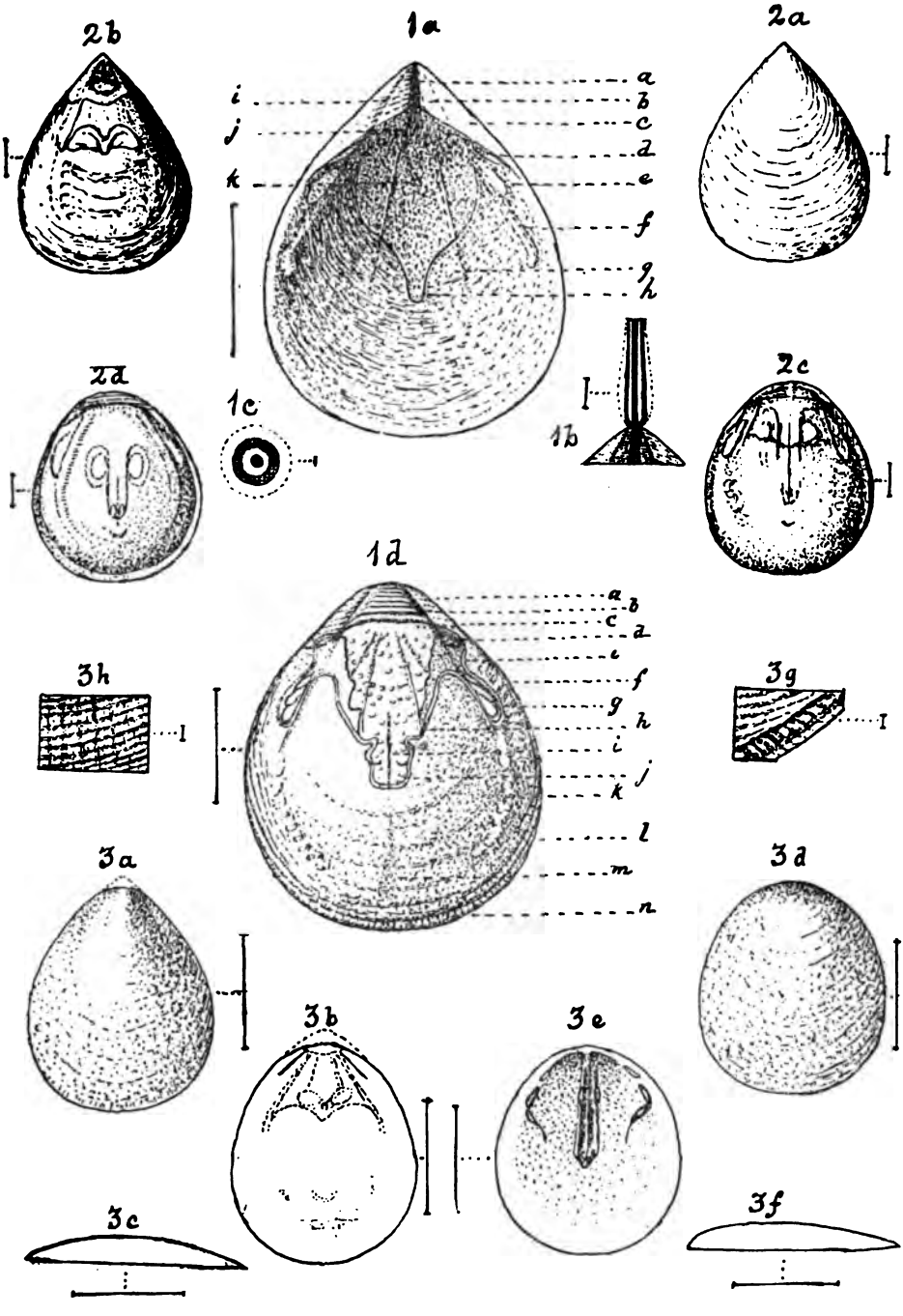
## *PLATE XV.*

FIG. 1. *Lingulella lævis* var. *grandis*, n. var.—*a* **Interior of ventral valve** (Legend, *a* Pedicle groove, *b* Pseudodeltidium, *c* Areal border, *d* Transmedian muscle-scar, *e* Scar of laterals, *f* Lateral septum, bordering vascular trunk, *g* Position of anterior adductor? *h* Front of visceral callus, *i* Deltidial suture, *j* Sinew of pedicle?—*k*, point of attachment of same?—Valve mag. $\frac{3}{4}$. *b*, **Cardinal area and pedicle** and pedicle mag. $\frac{4}{3}$ to show the core and muscular coat of the pedicle—*c* **cross section of same** Mag $\frac{1}{1}$". All from Band C. 3 *a* at St. John, N. B. See p. 200.

FIG. 1. *Lingulella lævis* var. *grandis*, n. var.—*d*, **Interior of the dorsal valve** partly exfoliated—(legend—*a*, Areal border—*b*, Deltidial suture—*c*, place of umbonal muscle,—*d*, umbonal scar?—*e*, parietal band—*f*, lateral branches of vascular trunks—*g*, transmedian muscle (?) laterals behind it, *h*, adductor muscles, *i*, median septum—*j*, anterior lateral muscle *k*, print of vascular trunks—*l*, mantle border—*m*, median sulcus, *n*, traces of vascular rays). Valve magnified $\frac{3}{4}$. From Band C. 3 *a*, at Escasonie shore, East bay, N. S. See p. 200.

FIG. 2; *Lingulella radula* var. *aspera* n. var.—*a*, ventral valve—*b*, mould of interior of same, mostly uncovered—*d*, another mould quite decorticated. All Mag. $\frac{2}{3}$. From Band C. 2 *c*, at McNeill brook, Mira river, N. S. See p. 204.

FIG. 3. *Lingulella lævis*, var. *lens*,—*a*, ventral valve *b*, mould of interior of same, *c*, longitudinal section of same—*d*. dorsal valve *e*, interior of same *f*, longitudinal section of same. All mag. $\frac{2}{3}$.—*g*, sculpture of a layer at the margin of the shell—*h*, sculpture toward the median line. Both magnified $\frac{1}{1}$. All from Band C. 3 *a* at Escasonie shore, East bay, N. S. See p. 201.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1d
3h
3g
3a
3d
3b
3e
3c
3f

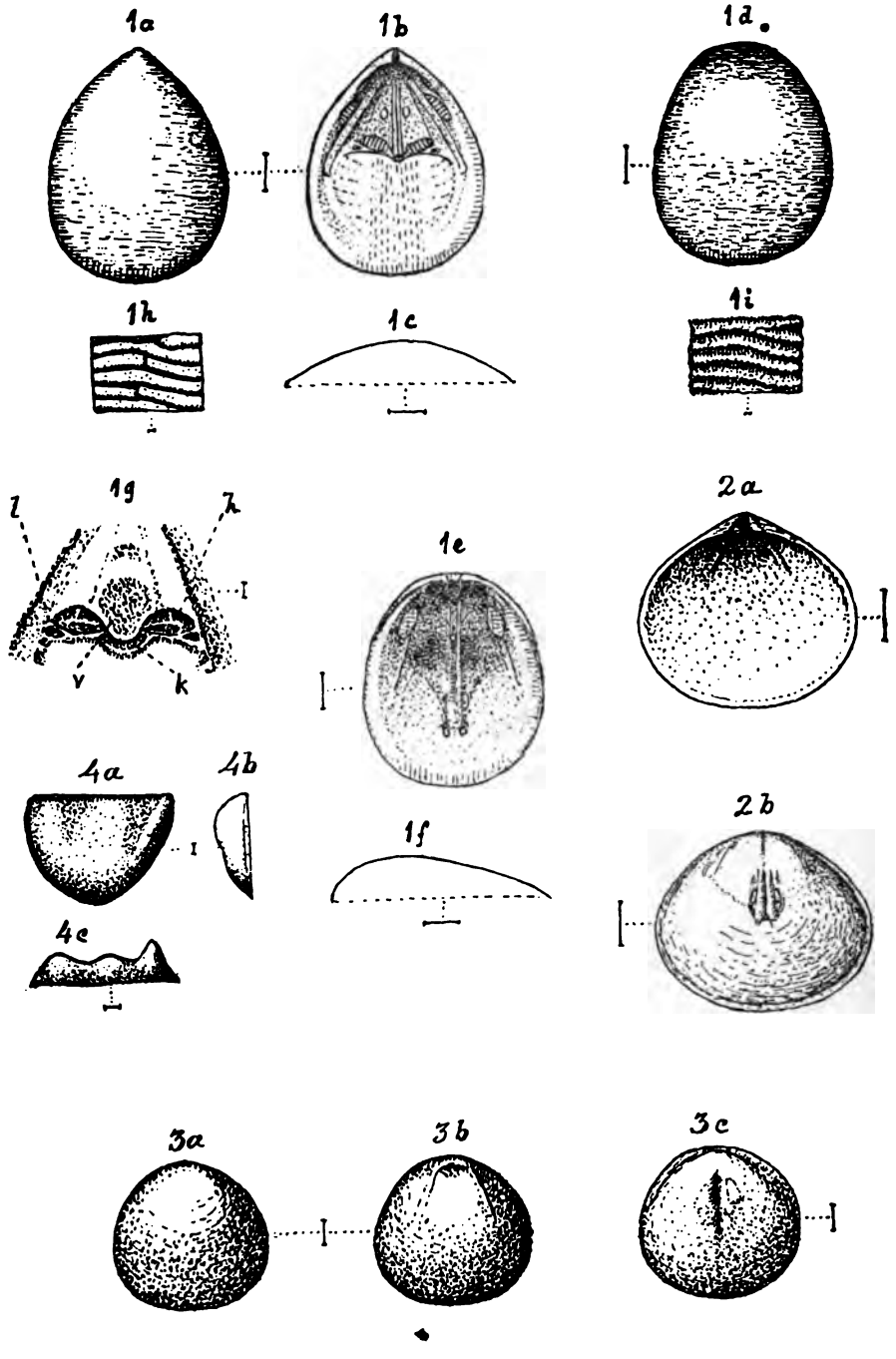
## *PLATE XVI.*

FIG. 1. *Westonia Escasoni*; —*a* Ventral valve; —*b* Interior of the same; —*c* Longitudinal section of same; —*d* Dorsal valve; —*e* Interior of the same; —*f* Longitudinal section. All Mag. $\frac{6}{1}$; —*g* Enlargement of visceral area of ventral valve to show the central group of muscle scars; —(Legend *h*, Anterior adductor and "k" lateral, *k* place of the sinew of the pedicle, *l* scar of the "l" lateral, *v* Front of the visceral callus.) Mag. $\frac{1}{1}^0$; —*h* Outer surface. Mag. $\frac{2}{1}^0$; —*i* Sculpture of second layer of the shell. Mag. $\frac{2}{1}^0$. All from Band C. 3*b*, Escasonie shore, East bay, N. S. See p. 206.

FIG. 2. *Monobolina refulgens.*—Interior of the ventral valve; —*b* Mould of interior of dorsal valve. Both Mag. $\frac{1}{1}$. From Band C 3*c*, McLeod brook, Boisdale, N. S. (See also Pl. xi, fig. 4.) See p. 210.

FIG. 3. *Linnarssonia* c.f. *Belti.*—*a* Ventral valve; —*b* Mould of interior of same; —*c* Mould of interior of dorsal valve. All Mag $\frac{6}{1}$. From Band C 3*c*, McLeod brook, Boisdale, N. S. See p. 209.

FIG. 4. *Beyrichia triceps*, n. sp.—*a* Right valve;- *b* Same from the front; - *c* Same from the ventral edge. All mag. $\frac{1}{1}^0$. From band C 2b, McLean brook, Mira river, N. S. See p. 219.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1b
1d
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1g
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v
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1e
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4a
4b
1f
2b
4c
3a
3b
3c

## *PLATE XVII.*

FIG. 1. *Orthis lenticularis*—*a* Ventral valve; —*b* Dorsal valve; —*c* Mould of interior of ventral (Legend, $a^1$ Adductor muscle, $b^1$ Diductor muscle, $d^1$ Cardinal area, $o^1$ Ovarian space); —*d* Mould of interior of dorsal (Legend $b^1$ Diductors, $d^1$ Cardinal area, $o^1$ Ovarian space). All mag. $\frac{2}{1}$. From Band C 3*c*, Navy island, St. John. See p. 213.

FIG. 2. *Orthis lenticularis* var. *lynxioides.*—*a* Young ventral valve; —*b* Full grown ventral; —*c* Small dorsal valve. All Mag. $\frac{2}{1}$. From Band C 3*c*, Navy island, St. John. See p. 217.

FIG. 3. *Orthis lenticularis* var. *atrypoides*—*a* Ventral valve; —*b* Dorsal valve. Both Mag $\frac{2}{1}$. From Band C 3*c*, Navy island, St. John. See p. 216.

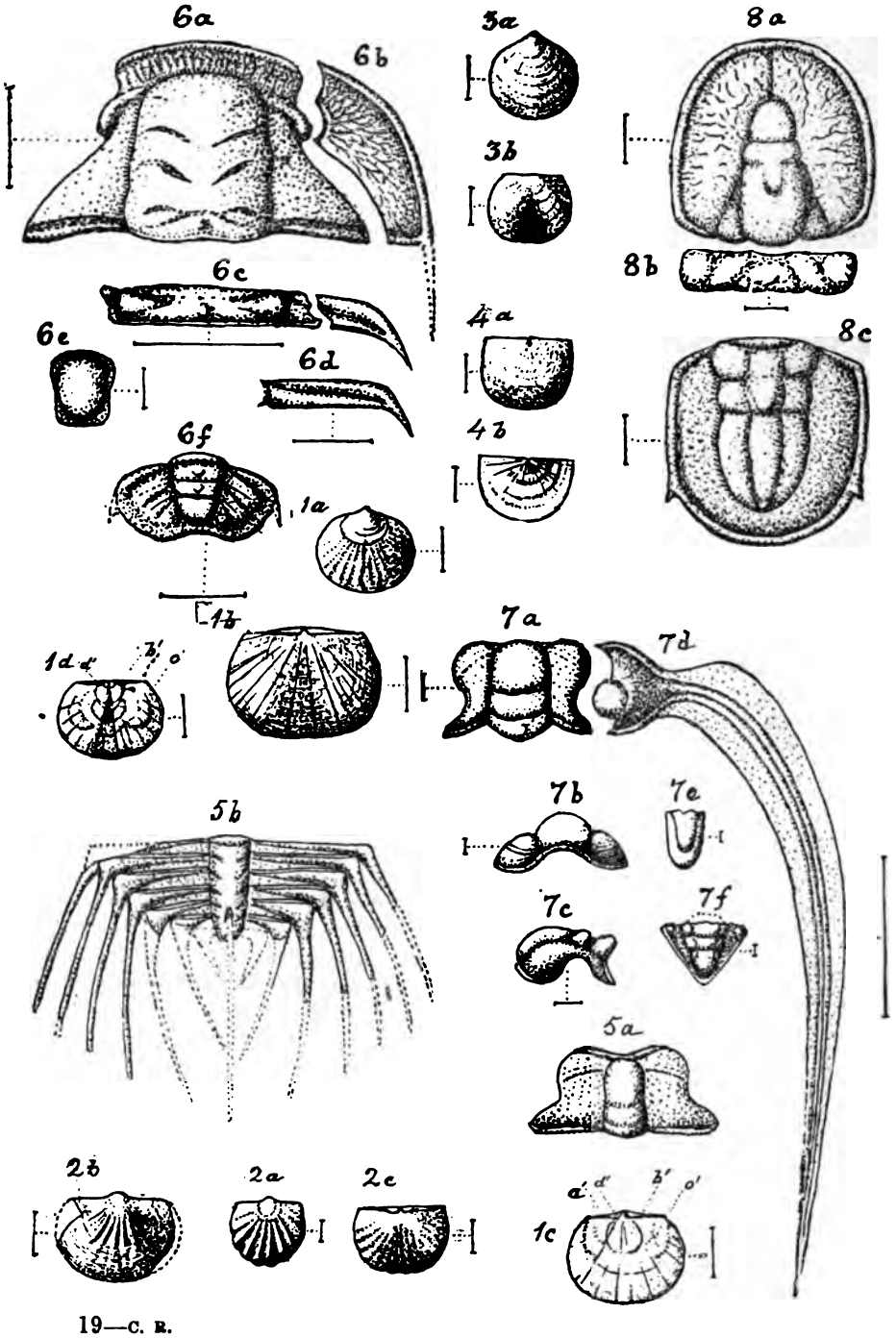
FIG. 4. *Orthis lenticularis* var. *strophomenoides*—*a* Ventral valve; —*b* Dorsal valve. Both Mag. $\frac{2}{1}$. From Band C 3*a*, Germain St., St. John. See p. 217.

FIG. 5. *Ctenopyge pecten*—*a* Middle piece of the head shield; —*b* Pygidium (After Linnarsson). Both Mag. $\frac{2}{1}$. The head from Band C 3*c*, at Escasonie shore, East bay, N. S. See p. 229.

FIG. 6. *Paraholina Dawsoni*—*a* Middle piece of head shield; —*b* Movable cheek; —*c* A front joint of the thorax; —*d* A pleura from the middle of the thorax; —*e* The hypostome; —*f* The pygidium. All mag. $\frac{2}{1}$. From Band C 3*b*. Escasonie shore East bay, N.S. See p. 223.

FIG. 7. *Sphærophthalmus Fletcheri*—*a* Middle piece of head shield; —*b* Same from the front; —*c* Same from the side; —*d* Movable cheek; —*e* Hypostome; —*f* Pygidium. All mag. $\frac{1}{1}$ except *e* and *f* which are $\frac{2}{1}$. From Band C, 3*b*, Escasonie shore, East bay, N. S. See p. 227.

FIG. 8. *Agnostus trisectus* Salt. mut. *ponepunctus* *a* Head shield; *b* Joint of the thorax; —*c* Pygidium. All mag. $\frac{4}{1}$. From Band C, 3*b*, Escasonie shore, East bay, N. S. See p. 220.


6a
6b
3a
3b
8a
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8c
6c
6e
6d
4a
4b
6f
1a
1b
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7a
7d
7b
7e
7c
7f
5b
5a
2b
2a
2c
1c

## *PLATE XVIII.*

FIG. 1. *Acrotreta sipo.* Section of the ventral valve, showing the siphon. See p. 185.

FIG. 2. *Acrotreta sipo.* Interior of the dorsal valve, showing the median septum. Both Mag. $\frac{3}{1}$, and from Assise C $c^2$, McLeod brook, Boisdale, N. S. See p. 185.

FIG. 3. *Bellerophon insulæ*—Sinistral side Mag. $\frac{3}{1}$. From Assize C $3c^2$, McLean brook, Boisdale, N. S. See p. 217.

FIG. 4. *Bellerophon Bretonensis*—*a* Dextral side; —*b* Broken valve, showing interior, &c. Both natural size; —*c* Dorsum, showing angle of the growth of lines. Mag. $\frac{2}{1}$; —*d* Part of surface of body wall. Mag. $\frac{4}{1}$. All from Assise C $3c^2$. McLeod brook, Boisdale, N. S. See p. 218.

FIG. 5. *Bellerophon semisculptus*—Showing the outer whorl Mag. $\frac{1}{1}$. From Assise, C $3c^2$, McLeod brook, Boisdale, N. S. See p. 219.

FIG. 6. *Urotheca*, sp. Tube, showing larval part and living chamber. From Assise, C $3c^2$, McLeod brook, Boisdale, N. S. See p. 183.

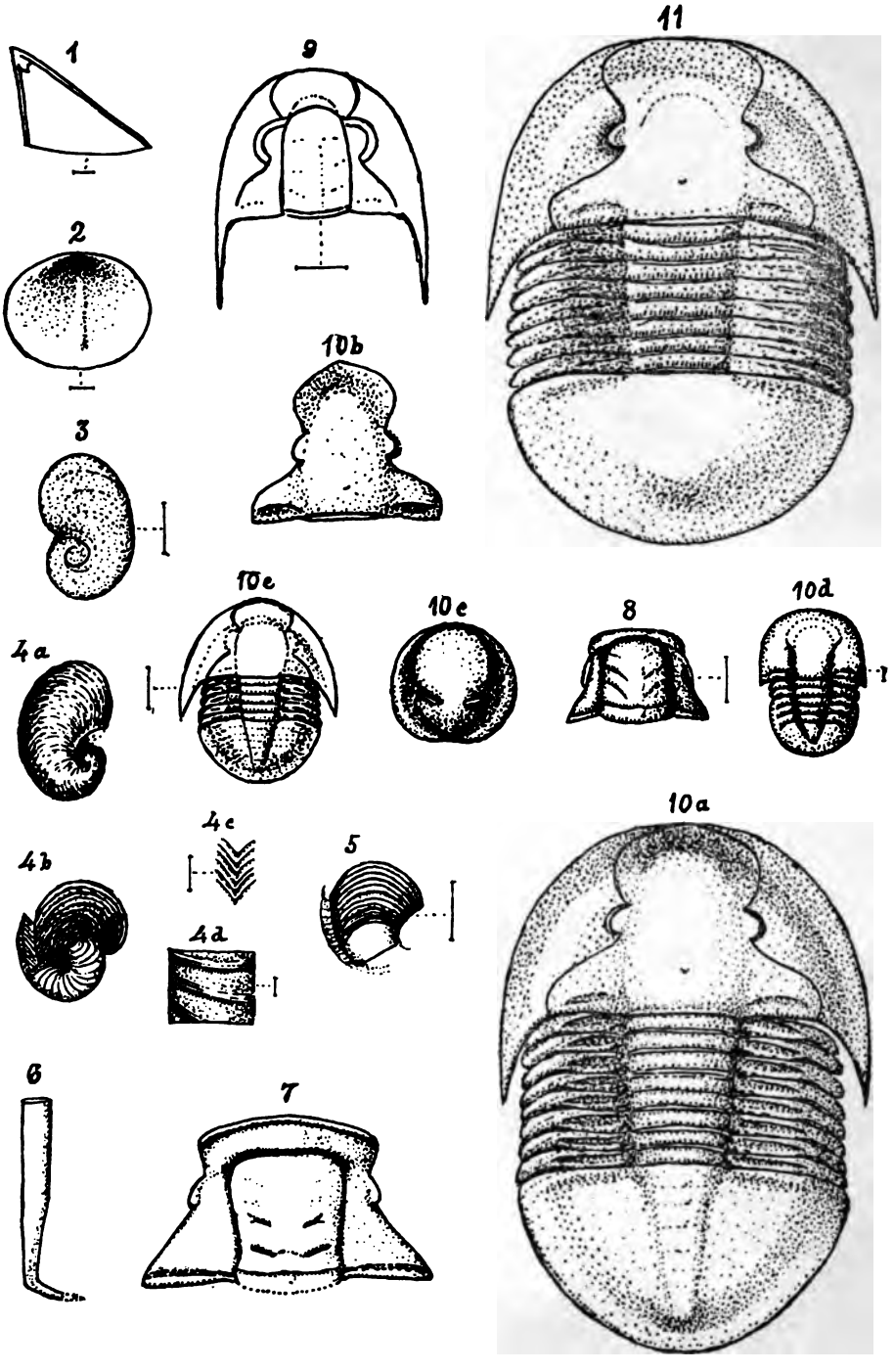
FIG. 7. *Parabolinella* (?) *quadrata*—Middle piece of head-shield. Natural size. From Assise C $3c^2$, McLeod brook, Boisdale, N. S. See p. 225.

FIG. 8. *Triarthrus Beili*—Middle piece of the headshield, right side and occipital ring restored. Mag. $\frac{2}{1}$. From Assise C $3c^2$, at McLeod brook, Boisdale, N. S. See p. 230.

FIG. 9. *Angelina* ? sp.—Larval cephalic shield. Mag. $\frac{4}{1}$. From Assise, C $3c^2$, McLeod brook, Boisdale, N. S. See p. 232.

FIG. 10. *Asaphellus Homfrayi, var.*—*a* Adult, broad form, partly restored; —*b* Middle piece of the headshield of the narrow form; —*c* The hypostome. All natural size; —*d* Early larval form. Mag. $\frac{10}{1}$; —*e* A later larval form Mag. $\frac{4}{1}$. All from Assise, C $3c^2$, at McLeod brook, Boisdale, N. S. See p. 232.

FIG. 11. *Asaphellus* (?) *planus.* Adult—Natural size; the pygidium enlarged from another example supposed to be of this species. From Assise C $3c^2$ at McLeod brook, Boisdale, N. S. See p. 237.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